ANALYSIS OF FUNCTIONAL OUTCOME AND FACTORS INFLUENCING THE OUTCOME OF *FLOATING KNEE INJURIES*

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DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE Dr. M.G.R MEDICAL UNIVERSITY, CHENNAI, FOR THE **DEGREE OF M.S.** BRANCH -II **(ORTHOPAEDIC SURGERY)** MARCH (2005-2007).

CERTIFICATE

This is to certify that this dissertation entitled **"FLOATING KNEE INJURIES An analysis of functional outcome and factors influencing the outcome"** is the bonafide record of work done by **Dr. J. Berin Jaba** under my supervision and guidance in the **Department of Orthopaedics and Accident Emergency Surgery, Christian Medical College, Vellore, during his 2 years (2005-2007) Master of Surgery branch-II (Orthopaedic Surgery),** in partial fulfillment of requirements for the award of Master of Surgery branch-II (Orthopaedics), by **the Tamilnadu Dr MGR Medical University**, **Chennai.**

This consolidated report presented herein is based on bonafide cases and studied by the candidate himself.

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Finally I record my gratitude to all the patients with their help and co-operation has made this work possible.

Berin Jaba. J

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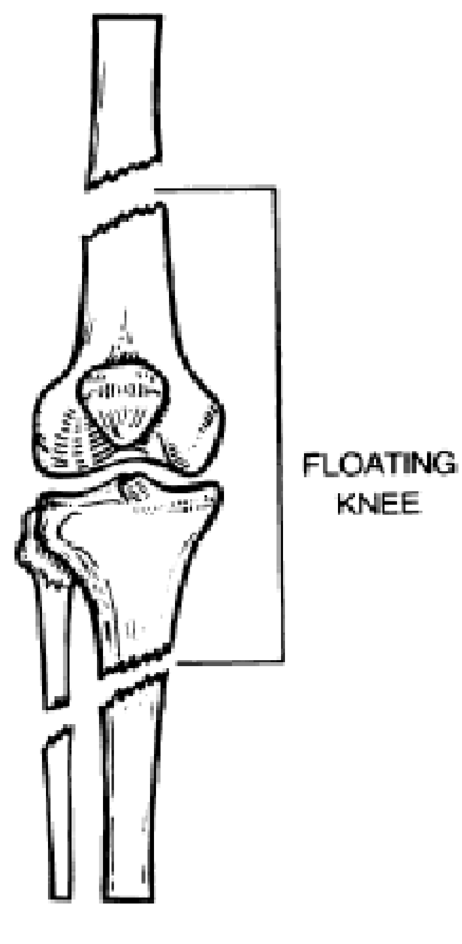


INTRODUCTION

Floating knee injuries were first described by McBryde in 1974 as fractures of ipsilateral femur and tibia[19]. This includes fractures of the shaft and or condyles of the femur and tibia. Later Winquist described these injuries as a flail knee joint segment resulting from a fracture of the shaft or adjacent metaphysis of the ipsilateral femur and tibia in 1984[17]. The most common mode of injury was due to a high velocity motor vehicle accident involving a two wheeler versus a four wheeler[17].

The incidence of floating knee injuries was reported as 2.6 % of all fractures by Letts et al in 1986 [16]. These injuries were associated with life threatening injuries such as head injury, chest injury and abdominal injuries as shown by Veith [27]. There was extensive soft tissue damage of the limb as well. Other skeletal injuries were also seen in these patients. Injuries were often a combination of different fracture patterns. The soft tissue injuries can also be variable from minor abrasions to grade III open injuries. Injuries to the neurovascular structures add a treacherous component to the whole picture. This often perplexes even the most experienced clinicians in the choice of management.

In short it may turn to be one of the most difficult injuries to evaluate and manage. A comprehensive team approach has been advocated as being essential. Following treatment the ultimate range of motion of the knee in an individual varies from ankylosis to full range of motion.

The established principles of treatment are.

1) Early and thorough debridement of the wound in case of open fractures.

2) Accurate reduction of intraarticular fractures and reduction of dislocations.

3) Stabilization of fractures with appropriate implants.

4) Concurrent management of neurovascular injury.

5) Primary or delayed primary closure of wounds and appropriate soft tissue cover.

6) Early mobilization of the knee joint and introduction of the functional activities of the lower limb as a whole.

For this dissertation thirty five patients with floating knee injuries from January 1999 to December 2003 were identified. They had received initial surgical treatment and subsequently after care by the Department of Orthopaedics and Accident Surgery at the Christian Medical College and Hospital, Vellore. These patients were assessed for the functional outcome of these injuries along with various factors affecting the outcome of their end results.

OBJECTIVES OF THE STUDY

1) To analyze the functional outcome of various types of floating knee injuries.

2) To identify the factors which influence the functional outcome of the floating knee injuries.

3) To analyze the incidence of ligamentous injuries associated with floating knee injuries.

ANATOMY AND BIOMECHANICS OF THE KNEE

Embryology:

Embryologically the knee develops from the leg by 28 days, with formation of the femur, tibia and fibula by 37 days. The knee joint arises from biastemal cells with formation of the patella, cruciate ligaments and menisci by 45 days. The knee formed by femur, tibia, and patella consists of three partially separated compartments called the patellofemoral, medial and lateral tibiofemoral compartments.

Femoral condyles:

The femoral condyles are asymmetric in size and shape. The medial femoral condyle is approximately 1.7 cm longer than the lateral femoral condyle in its outer circumference. In sagittal axis the lateral femoral condyle extends more anteriorly than the medial condyle and in coronal plane the medial femoral condyle projects farther distally than the lateral condyle. However in normal weight bearing alignment the condyles appear to be equal in level. The parallel femoral condylar surfaces are created by the mechanical axis configuration of the lower extremity. The weight bearing axis is a straight line from the centre of femoral head that intersects the centers of the knee and ankle joints. The distal femoral joint line forms a 6 degree valgus angle to the long axis of the femoral shaft, creating physiological valgus at knee.

Tibial plateau:

The tibial joint surface is complex. A normal tibial articulation includes the menisci to provide congruity to the distal femoral condyles. The menisci function to create conformity between the flat tibial and curved femoral surfaces. Biomechanically the menisci function to decrease the stress concentration of tibio femoral contact by increasing the surface area of contact between the femur and tibia during weight bearing. Without the menisci, the tibial and femoral articular surfaces would carry similar forces distributed over a smaller surface area resulting in stress concentration. The medial condyle is nearly flat and has a larger surface area than the lateral condyle. The lateral condyle surface is slightly convex. Both tibial condyles have a 10 degree posterior inclination to the tibial shaft in the sagittal plane. Bordering the femoral notch are the medial and the lateral tibial spines which stabilize the tibia from side to side motion. The interspinous area is devoid of hyaline cartilage and is the insertion site for the meniscal horns and cruciate ligaments. The cruciate ligaments insert on to this intertubercular sulcus and not on to tibial spine themselves.

Blood supply:

Vascular supply to the knee is a complex anastamosis of two separate systems namely the intrinsic and extrinsic networks. The intrinsic supply is an anastamotic ring made up of the articular, muscular and five geniculate arteries (superomedial superolateral, middle, inferomedial and inferolateral). The extrinsic system is made up of the descending branch of superficial femoral artery, recurrent branch of anterior tibial artery and the descending branch of the lateral femoral circumflex artery.

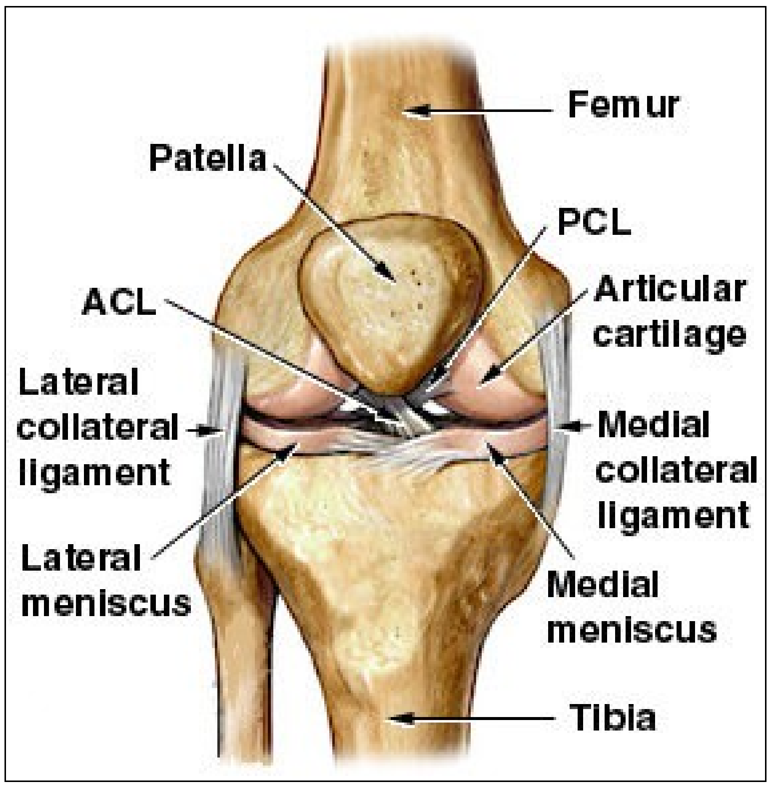
Nerve supply:

Nerve supply to the knee is from the branches of femoral nerve and of the sciatic nerve.

Ligaments around the knee joint:

The ligaments of the knee joint are divided functionally into a three layer system.

Figure 2: Anatomy of Knee joint



Layer I:

This is the fascial layer and is the most superficial. It is composed of an arciform layer anteriorly, the sartorius fascia medially, iliotibial band and biceps femoris laterally.

Layer II:

This contains the patellar tendon, the superficial medial collateral ligament and the lateral collateral ligament.

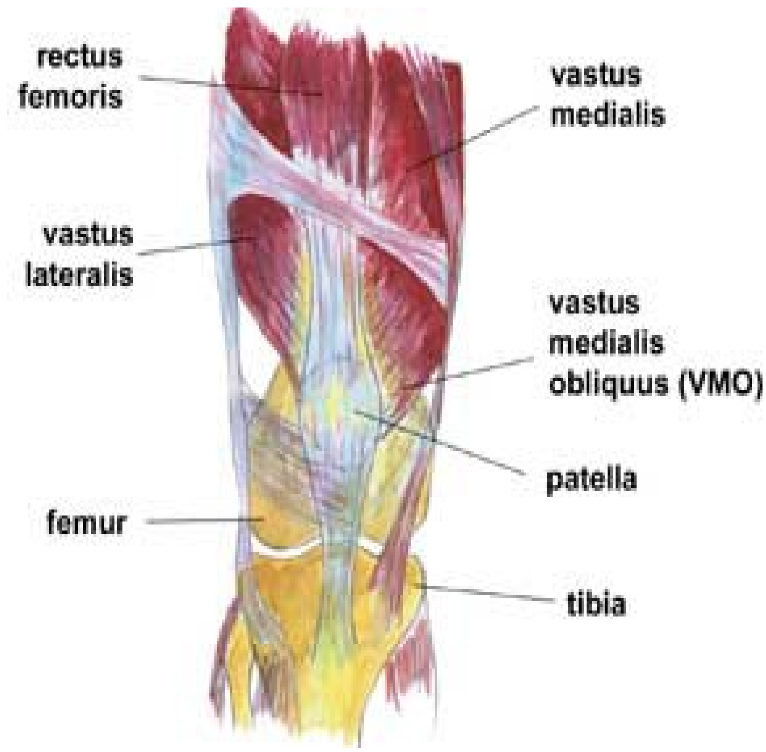
Layer III:

This is composed of the joint capsule including its functional capsular thickenings, the posterior oblique ligament, arcuate ligament and deep medial collateral ligament.

The anterior cruciate ligament is attached on the posterior and lateral aspect of the femoral notch as a semicircle rotated 25 degrees from long axis of the femoral shaft. The insertion of the anterior cruciate ligament on the tibia is narrow and long, measuring approximately 30 mm in length with attachments to the anterior horn of lateral meniscus. It has a synovial envelope and has been described as being extrasynovial but intraarticular. It is vascularised by the middle geniculate artery. It has two portions, the anteromedial and posterolateral band.

The posterior cruciate ligament originates from two anatomic sites on the anterior aspect of the medial femoral notch. It has two bundles the anterolateral and posteromedial which are named by the relative position of origin and insertion. The anterolateral bundle originates from the anterior aspect of the femur and inserts on the lateral aspect of tibia. The posterolateral bundle originates posterior to the anterolateral bundle on the femur and is inserted medial to it on the tibia.

Figure 3: **Anatomy of Quadriceps Muscle**



Meniscus:

The basic functions of the menisci are joint stabilization, tibio femoral stress reduction and joint nutrition. The meniscus is a tibial extension which creates conformity between the relatively flat tibial surface and the round femoral condyles. Both menisci are made up of type- I collagen with some type- III collagen. Collagen fibres lie in circumferential hoops and radial arrangements to create the structure of the menisci. Circumferential fibers function in hoops to accept stress while radial fibres stabilize the meniscus, preventing circumferential splits as well as resisting excessive compressive loads.

Muscles:

The quadriceps is composed of four muscles which are the rectus femoris, vastus lateralis, vastus medialis and vastus intermedius (Figure 3). They have a common tendinous insertion on to the patella. The rectus femoris crosses the hip joint originating from the anterior inferior iliac spine and forming the anterior portion of the quadriceps muscle tendon group. The vastus lateralis originates from the lateral surface of femur along the linea aspera and the lateral intermuscular septum. It has attachments to both the lateral aspect of patella and has an expansion to the iliotibial tract. The vastus medialis originates from the medial surface of proximal femur and inserts into the common tendon as well as the medial portion of the patella. The lower portion of vastus medialis originates from the tendon of the adductor magnus with the transverse fibres inserting into the patella. This part is called as vastus medialis obliqus. The vastus intermedius arises from the anterior surface of femoral shaft and blends with the medialis musculature and tendinous insertion. Quadriceps muscle forms trilaminar tendon, with the rectus anteriorly, vastus medialis and intermedius in the intermediate layer and the vastus lateralis in the deep layer.

The hamstring musculature is made up of the gracilis, semitendinosus and the semimembranosus medially and biceps femoris laterally. On the medial side the semimembranosus has a separate insertion and the gracilis and semitendinosus combine with the sartorius to create pes anserinus. The gastrocnemius is composed of two muscle bellies the medial and lateral. Both muscle bellies originate above the respective femoral condyles in the area of distal femoral physis. The tendinous part combines with the common tendon of soleus to form tendo achilles.

The motor function about the knee is important in understanding the gait as well as dynamic knee joint stability. The specific function of the quadriceps and hamstrings during walking is not to produce extension and flexion respectively, but actually the reverse. At heel strike the quadriceps eccentrically contracts allowing controlled flexion of the knee, absorbing impact energy. Likewise the hamstrings muscles fire eccentrically during swing phase to slow down the leg in preparation for heel strike, creating controlled extension of the knee. The gastrocnemius also has important functions in the gait cycle. Although a strong knee flexor, it functions eccentrically to decelerate the leg and body for heel strike. Once in stance phase the gastrocnemius controls knee flexion to prevent a back knee gait and finally at toe off it fires concentrically in conjunction with the soleus for producing push off.[24]

REVIEW OF LITERATURE

Floating knee injuries are uncommon. Proportionally there is also very little literature available. Extensive damage to the soft tissues, intra articular fractures, communition, segmental and open fractures makes management difficult. Generally the outcomes of these injuries are poor (Karlstrom and Olerud 1977 [15]).

For floating knee injuries in the 1970s and 80s, conservative management was favoured and surgical intervention with implant fixation was criticized. Complications such as non union, delayed union, osteomyelitis, knee stiffness and deformities were common.

A more rational approach to the management of these difficult injuries gradually evolved due to,

1) Better understanding of functional anatomy and biomechanics of the knee, femur and tibia.
2) Awareness of the associated injuries.
3) The advent of internal fixation devices.
4) Microsurgery for neurovascular injury.
5) Aggressive soft tissue management.

The incidence of this injury has come down in the developed world due to the better driving conditions and strict adherence to the rules of the road. It still remains common in other parts of the developing world.

Mechanism of injury:

The mechanism of floating knee injuries was first reported as being sustained when a cyclist was struck by the car bumper by Letts et al in 1986[17]. Photographs (details about the photographs were not explained by Letts) were taken and the possible biomechanical forces of the accident analyzed. The mechanism of injury was proposed as, initially the cyclists tibia and fibula is struck by the car bumper with the hip and knee almost fully extended. Then the thigh is struck by the front of the car, throwing the cyclist on to the bonnet, falling on to head suffering head injury. In addition if the limb is then run over there is degloving or crush injury [17]. Most of the cases reported showed that the right lower extremity was the most commonly involved side [13]. The study by Fraser showed left sided injury was more common than right sided injury due to the left handed driving[10].

Associated injuries:

Besides being caused by high energy trauma with extensive soft tissue injury to the limb they are also associated with potentially life threatening injuries of the head, chest and abdomen [28, 17]. Baker and associates evolved an Injury Severity Score to quantitate all the injuries[2]. This is an anatomical scoring system that provides an overall score for patients with multiple injuries. Each injury is assigned an Abbreviated Injury Scale (1 being minor, 5 severe and 6 a non survivable injury) and is allocated to each one of six body regions (Head, Face, Chest, Abdomen, Extremities and External injury) only the highest Abbreviated Injury Scale scoring in each body region is used. The three most severely injured body regions have their score squared and added together to produce the Injury Severity Score (ISS). Injury Severity Scores takes value from 0 to 75. This score is virtually the only anatomical scoring system and correlates linearly with mortality, morbidity, hospital stay and other measures of severity. Associated ipsilateral knee ligament injury was found in 5-39 % of patients in a study of twenty four patients[25]. These were assessed by clinical examination or Magnetic Resonance Imaging (MRI). The physeal fractures of distal femur and proximal tibia in children was described by Morley [21]. Periprosthetic floating knee injury was described in 2006 [14]. Floating knee injury associated with ipsilateral knee dislocation was described in a case report by Chenn in 1998.[6]

Classification:

Floating knee injuries were initially classified by Fraser et al in 1978 according to the fracture site and intraarticular extension into the knee joint as follows[10].

Type- 1: Both femoral and tibial shaft fractures with out extension into the knee joint.

Type- 2: Fractures extending in to the knee joint, it was sub divided into three types.

- A) Intraarticular fracture of tibia.
- B) Intraarticular fracture of the distal femur.
- C) Intraarticular fractures of both the femur and tibia.

Later in 1986 Letts et al analyzed fifteen patients with floating knee injuries and classified it into five types according to the location and nature of fractures (Table-1) [17]. Letts classification is favoured since it classifies the nature of injury either closed or open as well as the anatomical location of fractures. These factors have been shown to influence both the treatment and outcome.

Figure 4: LETTS Classification

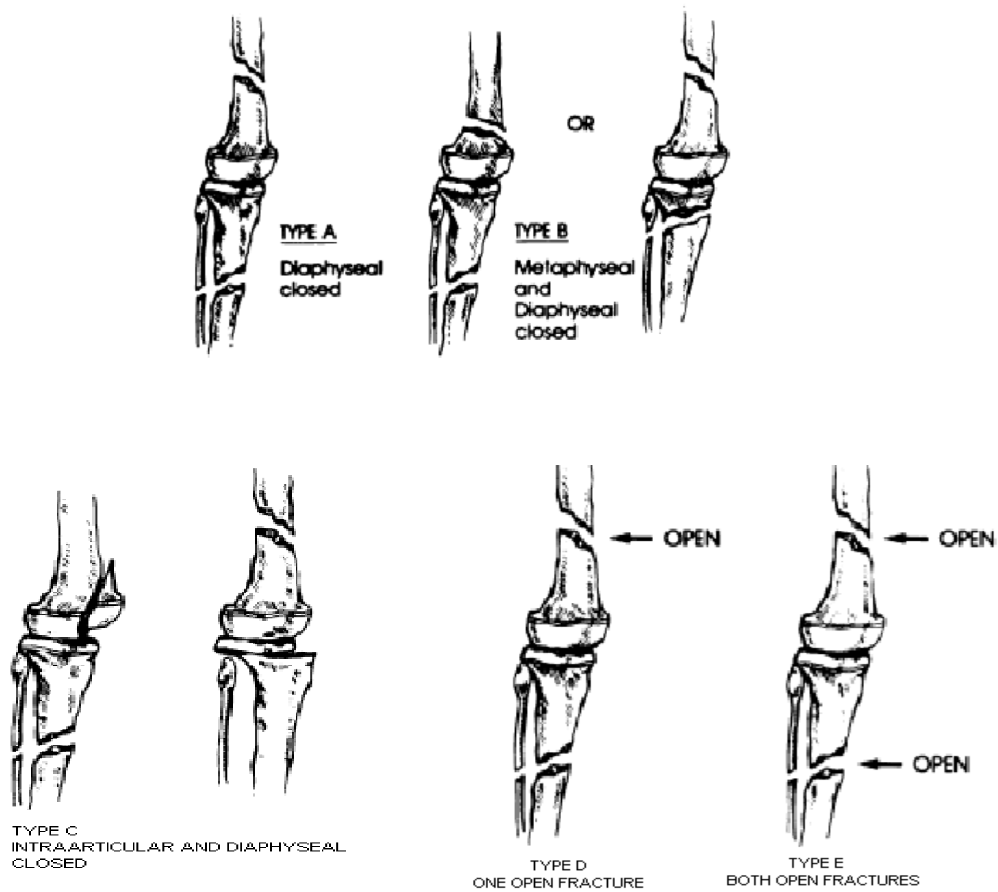


Table -1: Letts Classification

Type	Location	Nature of fracture
A	Both Diaphyseal	Both Closed
B	One Diaphyseal Other Metaphyseal	Both Closed
C	Intraarticular Extension in any One	Both Closed
D	Regardless of Site	One Open
E	Regardless of Site	Both Open

Management of floating knee injuries:

In 1975, Blake and McBryde reported a series of fourty seven patients[5]. Most of them were young men who had multiple injuries with high velocity trauma and complications of these fractures were frequent. Delayed union or non union occurred in 44.6% of the total number of bones involved. 60% to 70% of the adult patients showed significant permanent functional disability.

In 1977 Karlstrom and Olerud reported thirty two patients with floating knee injuries, fourteen patients were treated by rigid internal fixation or external fixation for both fractures[15]. Three patients had internal or external fixation of one fracture and conservative treatment of other fracture. Fifteen patients underwent non operative management for both fractures. The patients who were treated operatively for both fractures had a lower incidence of complications, shorter duration of hospitalization and shorter time to healing. An active surgical approach produced considerably better functional end results. Twelve of fourteen patients treated surgically, resumed their former occupations compared with four of thirteen patients treated non-operatively.

In 1978 Fraser reported two hundred and twenty two patients with ipsilateral fractures of the femur and tibia[10]. Patients were grouped according to the type of fracture and the method of treatment; sixty three patients were clinically examined. The worst results were in those following non operative management of both fractures. Following this, more use of external fixation and of cast bracing was recommended in the management of the fractured tibia. Internal fixation was advised for the femoral fractures. Clinical examination of the knee at post operative or follow up suggested that disruption of ligaments (collateral or cruciate ligaments) was a common occurrence and should always be suspected in the presence of recurrent knee instabilities.

In 1972, Winston reported twenty four patients who had non operative management[29]. Despite many complications the author felt that this treatment was safe. In 1977, Karlstrom and Olerud reported better end results with surgical treatment either by internal or external fixation[15]. In 1979, De Lee reported treatment of floating knee injuries in seventeen patients with cast bracing for both fractures as definitive management[7]. Shortening and malunion was common with this type of management. Although floating knee injuries were considered as a primary indication for internal fixation since 1977[15], Ul-Haque reported about one patient with Letts type E injury[26]. This patient was managed non operatively and the end result was better. This case was reported to make a plea for trial of non operative management before opting for primary internal fixation of such complicated fractures. The non operative approach was strongly advocated when the essential requirements for internal fixation cannot be met.

In 1984, Bansal reported fourty patients with floating knee injuries with the follow up of six months to two years[3]. He found that the results were comparatively better in those patients treated by cast bracing or when the fracture of the femur was stabilized internally. In all these patients fractures of tibia were treated nonoperatively. The final functional result was poor if the femoral fracture was situated in the condylar flare. Katada reported fourteen patients with floating knee injuries[16]. He found that intramedullary nailing of both femur and tibia gave good results. As communition is often severe in patients with floating knee injuries intramedullary nailing with Kuntscher nail may be difficult. He introduced a closed Enders nailing for femoral and tibial shaft fractures. Its advantages were that it was technically simple, has wide indications and results in rapid bone union with out knee stiffness.

In 1984, Veith et al reported about fifty seven patients, fifty six of those femoral fractures and half of the tibial fractures were treated with internal fixation[28]. These included open fractures also. He reported that overall a good or excellent functional result was achieved in about 80 % of those patients. The best results were achieved when both fractures were stabilized surgically. In 1986, Letts reported fifteen children with floating knee injuries and the end results were poor when both fractures were treated non operatively[17]. Hence he recommended that at least one of the fractures should be treated operatively.

In 1987, Behr described flexible intramedullary nailing for adult patients with shaft fractures and achieved good results[4]. In 1996, Gregory described retrograde nailing of the femur and unreamed nailing for the tibia[11]. Lobenhoffer in 1997 described a complex knee joint trauma which includes floating knee injuries with severe soft tissue injury, knee dislocation, vascular and neurological injury[18]. This was treated with soft tissue sparing minimal invasive reduction and fixation techniques to reduce the complication rate. Percutaneous plate fixation, percutaneous screw osteosynthesis and hybrid fixation should be widely used in these patients. In knee dislocations, the central pivot with the two cruciate ligaments should be reconstructed using augmented repair or primary tendon grafting in every patient (The treatment of collateral ligament lesions depend on the specific injury type).

In 2000, Ostrum described percutaneous single incision retrograde nailing of femur and antegrade nailing of tibia. This gives good results[22]. Rethnam in 2006 reported that irrespective of ligament injury due to the procedure itself, the single incision nailing for the floating knee injuries produce good results [23].

Management of associated injuries in knee:

In 1991 Van Raay reported 31% of incidence of ligament injuries in fourty seven floating knee injury patients[27]. Disruption of knee ligaments had not been recognized initially. At the time of initial treatment, injury to the knee ligaments had been diagnosed only in three patients. After stabilization of both fractures in those patients, the anterior cruciate ligament was reconstructed. At follow up clinical examination, those patients had no knee instability. In view of high incidence of missed ligamentous injuries, the possibility of disruption of the knee ligaments should be considered in all patients with fractures of both femur and tibial shaft. The incidence of meniscal injury was not reported. He advised re-examination of the knee joint for ligament disruption after stabilization of femur and tibia. Early surgical repair of peripheral tears of the meniscus should be done. Repair of an anterior or posterior cruciate ligament without proximal or distal avulsion is not being warranted. He also described that knee instability was the major cause for poor end results. The knee joint dislocation and vascular injury were treated with reduction of dislocation, early exploration and repair of blood vessels. The soft tissue injuries were reconstructed with split thickness skin grafting or flap cover.

Management of other fractures:

Other related fractures like the ipsilateral neck of femur fracture, intertrochanteric fractures are treated with internal fixation. Other injuries like fracture of patella and malleolar fractures are also treated with internal fixation.

Current concepts:

Keeping with the current trends in the management of fractures and soft tissue injuries around the knee, the following management principles have been proposed for different injury patterns.

Intra articular fractures:

In intraarticular fractures the prime objective is reconstruction of the articular surface. The distal femoral fractures are classified according to AO classification.

Type A: - Extraarticular

Type A1- Simple two part fracture

Type A2- Metaphyseal Wedge.

Type A3- Metaphyseal complex comminuted.

Type B: - Partial articular

Type B1- Lateral condyle in sagittal plane

Type B2- Medial condyle in sagittal plane

Type B3- Fracture of both condyles in coronal plane

Type C: - Complete intraarticular

Type C1- Articular simple, metaphyseal simple

Type C2- Articular simple, metaphyseal multifragmentary

Type C3- Multifragmentary intraarticular.

The treatment options of the types are discussed below.[24]

For A1, A2, A3 fractures – Internal fixation by 95 degree blade plate or Condylar screw or Ante grade or retrograde nailing or Limited contact dynamic compression plate (LCDCP) can be used.

For B1 and B2 fractures- Internal fixation by interfragmentary lag screw with or with out buttress plate can be used.

Type B3- fractures are fixed with interfragmentary lag screws.

For C1, C2 and C3 fractures- Interfragmentary lag screw, 95 degree blade plate/ condylar screw/ antegrade or retrograde nailing along with reconstruction of articular surface by Kirschner wires or cancellous screws.

The proximal tibial intra articular fractures are classified by Schatzker as follows.[24]

Type 1 - Split fracture of the lateral tibial condyle

Type 2 - Split and depressed fracture of the lateral tibial condyle.

Type 3 - Isolated depression of the lateral plateau.

Type 4 - Fracture of the medial condyle.

Type 5 - Bicondylar fracture with varying degree of depression and displacement of the tibial condyles.

Type 6 - Bicondylar tibial fracture with diaphyseal- metaphyseal dissociation.

Treatment option:

Type 1 -Open reduction with buttress plate or closed reduction and percutaneous screw fixation under image intensifier control.

Type 2 -Open reduction, elevation of articular fragment with or without bone grafting and internal fixation with buttress plate.

Type 3 -Closed reduction or arthroscopic reduction and internal fixation with screws with or without bone grafting. Nonoperative management in older age group.

Type 4 -Open reduction and buttress plating or closed reduction and percutaneous fixation with screws.

Type 5 -Closed reduction, minimal internal fixation with screws and ring fixator. Rarely open reduction and dual plating applied.

Type 6 -Closed reduction, minimal internal fixation with screws and ring fixator.

Management of open fractures:

Open injury to the knee joint resulting from floating knee injuries require the same attention as is given for any other major joint. In the earlier preantibiotic era, sepsis destroyed the well meaning technical expertise of surgeons who encountered these in their practice. Therefore prevention of wound sepsis will always remain the prime objective in the management of all open fractures[12]. This can be a far cry in the developing world where patients present late or referred late.

It is universally agreed that, open fractures require emergency treatment which includes adequate debridement and irrigation of the wound. Beyond these two basic tenets there is difference of opinion as to the following.

1) Primary or secondary wound closure.

2) Use of primary internal fixation.

Open fractures in long bones have been suitably classified by Gustilo- Anderson.[12]

Type 1: Open fractures with wound less than 1cm long and clean.

Type 2: Open fractures with laceration more than 1cm with out extensive soft tissue damage, flaps or avulsions.

Type 3: High velocity injuries, an open segmental fracture, open fractures with extensive soft tissue damage or a traumatic amputation.

- A- Adequate soft tissues cover despite high energy open fracture.
- B- Extensive soft tissue stripping and contamination.
- C- Open fracture with vascular injury requiring repair.

In the past, many of the type 3 injuries would have been considered unsalvageable and limbs amputated because of ischemia or infection. Successful management of these injuries requires urgent revascularization, skeletal stabilization and aggressive soft tissue management.

Complications:

Complications of floating knee injuries are several in number and nature. Broadly they are classified into early and late.

A) Early

1) Neurovascular injury
2) Fat embolism.
3) Compartment syndrome.
4) Infection and sepsis.

B) Late

1) Osteomyelitis.

2) Knee stiffness.

3) Malunion and non union.

4) Shortening

Fat embolism syndrome:

Fat embolism syndrome is a major cause of morbidity and mortality in multiply traumatized patients who have sustained fractures. Fat embolism syndrome involves multiple organ systems and can cause devastating clinical deterioration within hours. Gurds criteria are used for the diagnosis of fat embolism. It is subdivided in to major and minor criteria. A major criterion includes axillary or subconjunctival petechiae, hypoxemia (PaO2 less than 60mmHg), central nervous system depression disproportionate to hypoxemia and pulmonary edema. Minor criteria includes tachycardia, pyrexia, emboli present in retina on fundoscopic examination, fat in urine, sudden drop in platelet or hematocrit , increase in erythrocyte sedimentation rate and fat globules in sputum. Diagnosis requires one major criteria and four minor criteria. Schiedts et al described 12% incidence of fat embolism syndrome in floating knee injuries, mainly due to reaming of both femur and tibia during intramedullary nailing[25].

Infection and sepsis:

The primary goal in the treatment of all open fractures is asepsis. Thorough debridement, reduction and stabilization of the fracture should be followed by early soft tissue cover. Appropriate antibiotic cover is given. If there is any doubt about infection, second look debridement of the wound is carried out every 24 to 48 hours till the wound settles. Established osteomyelitis needs specific antibiotics on sensitivity reports and curettage and sequestrectomy if necessary.

Neurovascular injury:

The incidence of neurovascular injury in floating knee injuries is not reported in the literature. All the vascular injury patients are diagnosed by clinical examination and by Doppler. The treatment of choice is exploration and primary repair or grafting of the arteries. If the vessels are thrombosed thrombectomy is done. Fasciotomy is done if indicated. The nerve injuries are treated according to the type of injury patterns and nature of the wound whether closed or open. Primary or delayed primary repair is done for the patients with neurotemesis and non operative management is required for patients with neuropraxia.

Compartment syndrome:

It is a serious complication and should be detected early. It is suspected when pain persists after immobilization, adequate analgesics have been administered, and there is increased pain on passive stretching of the muscle group involved. Tight bandages are removed and compartment pressures measured. Indications for fasciotomy are 1) Normotensive patients having clinical features of compartment syndrome and compartment pressure more than 30 mm Hg. 2) Duration of increased pressure not known or are more than 8 hours and 3) Unconscious patients with compartment pressures more than 30 mmHg.

Malunion and non union:

In the late 70s Fraser described more than a 30% incidence in delayed union or non union due to the non operative treatment[10]. But this incidence gradually reduced due to operative management with internal fixation. Malunion is mainly due to communition[13]and also seen in intramedullary fixation without interlocking (most commonly rotational malunion) of both the femur and tibia [25].

Knee stiffness:

Knee stiffness is the commonest disability. It may result from,

1) Bony block due to improperly reduced intra articular fractures.

2) Periarticular fibrosis due to surgery, trauma, implants.

3) Extra articular causes like quadriceps fibrosis or adherence.

4) Infection and

5) Prolonged immobilization[13].

Shortening:

Shortening usually follows communition, segmental fractures, traumatic bone loss and bone loss secondary to infection.

MATERIALS AND METHODS

This is a retrospective study of floating knee injuries treated at the Department of Orthopaedics and Accident Surgery Christian Medical College Hospital Vellore between January 1999 and December 2003. Floating knee injuries were first described by McBryde in 1974 as ipsilateral fractures of femur and tibia which include combinations of diaphyseal, metaphyseal and intraarticular fractures[20]. According to the classification by McBryde [20], fourty nine patients qualified for the study.

Inclusion criteria:

1) Patients with floating knee injuries presented in Accident and Emergency Medicine Department within 24 hours of injury.

2) Patients with minimum follow up of 2 years after the injury.

Exclusion criteria:

1) Patients with femoral fractures proximal to the subtrochanteric level.

2) Patients with tibial fractures distal to the distal metaphysis.

All patients presented in Accident and Emergency Department had a primary survey of Airway, Breathing, Circulation, and all these patients were resuscitated in the Emergency Department. A Secondary survey was done as soon as the patient was stabilized haemodynamically after resuscitation. All fractures were splinted with a Thomas splint or a Plaster of Paris slab and open fractures were irrigated and washed with at least 5 liters of sterile normal saline. All open fractures were given tetanus prophylaxis and antibiotic injections Cloxacillin, Penicillin and Gentamycin in divided doses according to the weight of the patient. Primary care was given to all these patients and they were operated by one or two surgeons with at least 3 years of experience under the guidance and supervision of other senior surgeons.

Letts classified floating knee injuries in to five types (type A to type E) according to the level of fractures and type of injury (closed or open) [17].

Type A - Diaphyseal and closed fractures of the femur and tibia.

Type B - One diaphyseal fracture and other metaphyseal fracture.

Type C - Both closed fractures with intraarticular extension in at least one bone.

Type D - Open fracture in one bone irrespective of the site of fracture.

Type E - Both open fractures irrespective of the site of the fractures.

Fourty nine patients had been consecutively treated during this period, according to Letts [17] classification these were type A- Four patients, type B- one patient, type C- Eleven patients, type D- Twenty six patients and type E- Seven patients. A total of fourty six males and three females, thirty four patients had right side floating knees and fifteen patients had left sided floating knees. The commonest mode of injury was a motor vehicle accident as was seen in fourty seven patients, (two wheeler versus four wheeler was more frequent), and two patients had fallen from a tree. The age ranged from 5 to 55 years, three patients were less than 18 years. The mean age was 34.5 years, thirty four patients had injury to the right lower limb and fifteen patients had injury to the left lower limb.

Patients were sent letters requesting them to come back for follow up. Thirty five patients were followed up and relevant history was collected. They were clinically examined, plain radiographs were taken of the pelvis with the hip, femur, tibia and knee joint in anteroposterior and lateral views. All these patients were assessed by using their outpatient, inpatient, operation records and X- rays which were taken during their course of the treatment.

The patients who did not come for follow up were excluded from the study. Finally thirty five patients were analyzed in this study; this includes type- A three patients, type- B no patients, type- C eight patients, type- D eighteen patients and type- E six patients. The details of preoperative status like mode of injury, fracture patterns, closed or open injuries, and any associated injuries were also evaluated.

Age distribution:

The age distribution of patients ranged from 5 years to 55 years of age with an average of 34.4 years.

Gender:

Thirty three patients were males (94.2%) and two patients were females (fig-5).

Distribution according to involved site

Twenty three patients had right sided injury and twelve patients had left sided injury (figure-6).

Mode of injury:

The mode of injury was high velocity motor vehicle accident in thirty four patients (a two wheeler versus a four wheeler was the most common) and one patient had fallen from a tree.

Figure 5: Gender Distribution

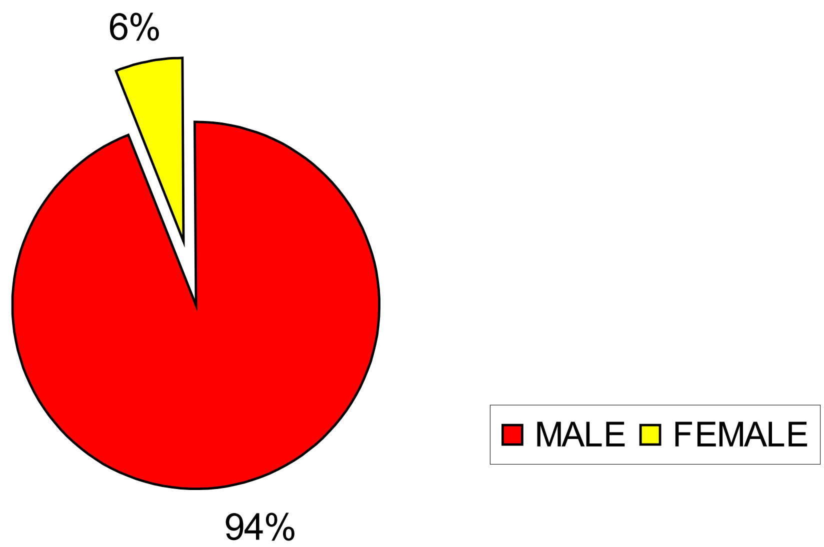
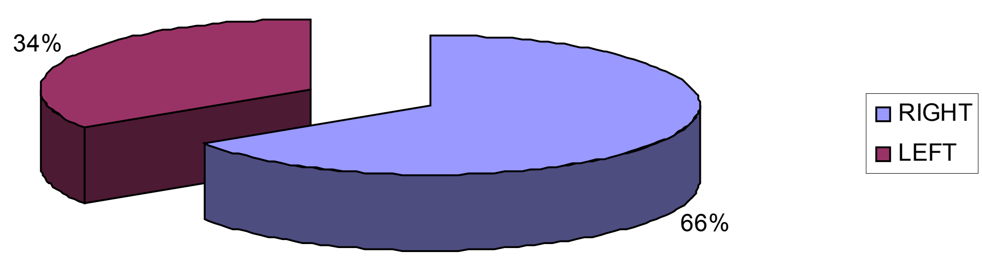


Figure 6: Injury Side Distribution



Classification:

According to Letts [17]classification(Table- 2), type A injuries - three patients, type B injuries - no patient, type C injuries - eight patients, type D injuries- eighteen patients and type E injuries- six patients, were analyzed in this study.

Table 2: Distribution according to LETTS Classification

Letts classification group	**Number of patients**	
	Initial group	**Study group**
A	4	3
B	1	0
C	11	8
D	26	18
E	7	6
Total	49	35

Fracture type:

Open fractures were classified using the Gustilo Anderson system (Table- 3) and closed fractures were classified using the Tscherne classification system. Closed fractures were seen in eleven patients (Table- 6), eight of them had intra articular fractures and three patients had extra articular fractures.

Table 3: Distribution according to Gustilo and Anderson classification

Fracture type	**No of Patients**
Type-1	0
Type-2	2
Type-3A	14
Type-3B	6
Type-3C	2
Total	24

Twenty four patients had presented with open fractures (Tables- 4, 5), of these eight patients had intra articular fractures. In these two patients had intra articular fractures in both bones (all patients had open type 3 femoral fractures).

Table- 4: Extraarticular and Intraarticular fractures

Fracture Type	Total Patients	Open	Closed
Extraarticular	19	16	3
Intraarticular	16	8	8

Table 5: Distribution of Open fractures

Fracture type	No.
Both femur and tibia open 3-A	3
Femur open 3A and tibia open 3B	2
Both femur and tibia open3-B	1
Femur closed and tibia open 3-A	8
Femur closed and tibia open type-2	2
Femur closed and tibia open type -3C	2
Femur open 3A and closed tibia	3
Femur open 3B and closed tibia.	3
Total	24

Nineteen patients had extra articular fractures (Table- 4). Twelve patients had an intraarticular fracture in which only one bone was involved, and four patients had fractures of both the lower Femur and upper Tibia with an intraarticular extension.

Table 6: Distribution according to Tscherne Classification

Tscherne Type	No of Patients
Type-0	0
Type-1	6
Type-2	4
Type-3	1
Total	11

Table 7: Number of Closed and Open fractures

Fracture Type	No of Patients
Both Open Fractures	6
Both Closed Fractures	11
One Open or Closed Fractures	18
Total	35

Fracture pattern:

Segmental fractures were seen in eleven patients. One patient had both femoral and tibial segmental fractures; all the other patients had segmental fractures in one bone.

Communition was classified according to Winquist et al; we considered type 3 and 4 for communition (Hee Tak et al [13]). Comminuted fractures were seen in twenty patients, in these four patients had both femoral and tibial communition and the others had a comminuted fracture in one bone.

Associated injuries:

Twenty two patients had fourty six associated injuries.

1) Vascular injury was seen in three patients (two patients had an above knee amputation and one patient underwent a fasciotomy).
2) Ligamentous injuries were seen in eight patients, six patients had anterior cruciate, and two had posterior cruciate ligament injuries.
3) Other ipsilateral injuries were seen in eighteen patients (Table- 8). Seven of them had a fractured patella, two of them had fracture neck of femur, two patients had an intertrochanteric fracture and two patients had a metatarsal fracture. One patient had a dislocation of the knee joint, one had a bimalleolar fracture, one had a tibial plafond fracture, one had a lisfrancs fracture dislocation and one patient had a tendo achilles rupture (Table- 8).

Table 8: Distribution of Other ipsilateral injuries

Nature of injury	Number of patients
Fracture patella	7
Fracture neck of femur	2
Intertrochanteric fracture	2
Metatarsal fracture	2
Knee dislocation	1
Tibial plafond fracture	1
Bimalleolar fracture	1
Lisfrancs fracture dislocation	1
Tendo achilles rupture	1
Total	18

4) Contra lateral lower limb injuries were seen in four patients, two patients had type- 3B open tibial fractures and two patients had closed tibial fractures.

5) Other associated injuries were seen in twelve patients (Table- 9). Two of them had rib fractures (one had a haemothorax), fracture clavicle were seen in two patients, metacarpal fractures seen in two patients. one patient had a pelvic fracture, one patient had a C2 fracture with quadriparesis, both bones fracture in the forearm in one patient, a distal radius fracture in one patient and a brachial artery thrombosis in one patient (this patient had undergone a brachial artery embolectomy).

Table 9: Distribution of Other associated injuries

Other injuries	No of patients
Rib fractures	2
Clavicle fracture	3
Metacarpal fracture	2
C2 fracture with quadriparesis	1
Pelvis fracture	1
Both bones fracture forearm	1
Distal radius fracture	1
Brachial artery thrombosis	1
Total	12

Time to admission in Emergency department after injury:

Time to admission ranged from 1 hour to 23.5 hours with a mean of 4.9 hours.

Injury Severity Score: (Table-10)

All patients were assessed according to the injury severity score[2] during admission in the emergency department, their scores ranged from 16 to 45 with a mean of 16.85.

Table 10: Distribution of Injury Severity Score

ISS	No. of Patients
16	33
45	2
Total	35

MESS score:

MESS Scoring was also done at admission in the Emergency Department. The scores were (Table-11) 3 in twelve patients , 4 in ten patients , 5 in seven patients , 6 in three patients , and 7 and above in three patients , of these two patients underwent an above knee amputation.

Table 11: Distribution of MESS Score

MESS Score	No of patients
3	12
4	10
5	7
6	3
7 and above	3

Time to surgery:

The time to surgery after injury ranged from 11 hours to 170 hours, two patients who had both closed fractures, the surgery was delayed for 5 days because of hypovolemic shock secondary to haemothorax in one patient and quadriparesis in other patient. The mean time to surgery was 42.6 hours (after excluding these two patients the mean time to surgery was 30.45 hours). Most of the patients had surgery within 20-40 hours after the injury.

Definitive management:

All the patients underwent an emergency surgical procedure with internal, external or a combined mode of treatment depending up on the clinical status of the patient, severity of open fractures, degree of communition of fractures, presence of segmental fractures, presence of metaphyseal and intraarticular fractures. All the soft tissue defects were reconstructed using a muscle flap or allowed to granulate, and a split thickness skin grafting was done primarily, or as staged procedures. All the open fractures were debrided in the Emergency Department, and subsequently thoroughly debrided under anesthesia in the operation theatre any further procedure was done as required by each case. Subsequent operations were done in twenty four patients, ten of them had refixation of tibial fractures (two patients needed three operations and one patient needed four operations) and three patients had to undergo revision fixation of their femoral fractures.

Follow up:

All patients were followed up at 3 weeks, 6 weeks, 12 weeks, 6 months and one year post operatively. During the follow up period, patients were examined by a surgeon clinically and radiologically. Time to full weight bearing in months was calculated from the records, time to bony union was also calculated in months according to radiological union. Malunion is defined as 10 degrees or more of malrotation either axial or angulatory [13]. Delayed union was defined as failure of evidence of union radiologically by 4 to 6 months. The knee range of motion was measured as active and passive range of movement. Poor range of knee flexion was defined as flexion less than 100 degrees. Subjective symptoms like knee pain, hip pain, ankle pain, leg pain and thigh pain were obtained. Two patients were ambulating with crutches at the time of assessment as one of the fractures had not consolidated completely. Ligamentous laxity was examined clinically by anterior drawers, posterior drawers and valgus and varus stress tests.

Limb length discrepancy was measured by comparing the measurement with the normal limb. Articular reduction was measured by evaluating post operative X- rays and by taking follow up X rays with both knees in anteroposterior, and lateral view both in the standing position. Photographs in the squatting position and standing position were also taken at the time of follow up. Functional assessment of the end results were evaluated by using Karlstrom and Olerud criteria (Table- 12)[15]. Seven standard criteria were used to assess the functional outcome of floating knee injuries. These were 1) Leg symptoms (further divided in to no symptoms, intermittent symptoms, severe symptoms and rest pain), 2) Knee and ankle symptoms (further divided in to no symptoms, intermittent symptoms, severe symptoms and rest pain), 3) Walking ability (further divided in to unimpaired, intermittent impairment, restricted walking ability and walking with a cane or crutch) 4) Work and sports (further divided in to unchanged premorbid work and sports, less than premorbid status, change to less work and permanent disability, 5) Angulation further divided in to no angulation, angulation less than 10 degrees, 10 to 20 degrees of angulation and more than 20 degrees angulation , 6) Limb length discrepancy further sub divided into no limb length discrepancy, less than 1cm, 1cm to 2cms and more than 2cms, and 7) Restricted range of movements further sub divided into normal range of movement; ankle movement restricted by 10 degrees; hip and knee restricted by 20 degrees; ankle restricted by 10 to 20 degrees; hip and knee restricted by 20 to 40 degrees; and ankle restricted more than 20 degrees; hip and knee restricted more than 40 degrees. Patients who fulfilled all the excellent criteria were rated as Excellent; patients who fulfilled all good criteria were rated as good. The outcome was fair or acceptable if the patient had at least one fair criterion and no poor criteria. The poor outcome group consists of patients who had one or more poor criterion.

Table 12: Functional Assessment of End results by Karlstrom and Olerud.

Functions	Excellent	Good	Fair	Poor
Leg symptoms	Nil	Intermittent signs	More severe	Rest pain
Knee, ankle symptoms	Nil	Intermittent signs	More severe	Rest pain
Walking ability	Unimpaired	Intermittent signs	Restricted	Crutch or cane
Work and sports	Same as pre injury	Less work	Change to less work	Permanent disability
Angulation	Nil	Less than 10 degrees	10—20 degrees	More than 20 degrees
Limb length discrepancy	Nil	<1Cm	1-3Cm	>3Cm
Restricted Range of motion	Nil	<10 Ankle. <20 Hip & knee	10-20Ankle 20-40 hip, knee	>20 Ankle >40 hip, knee

RESULTS

Thirty five patients came for follow up during the evaluation in 2006. They were classified according to Letts [17]classification, Type A- Three patients, Type B- nil patient, Type C- Eight patients, Type D- Eighteen patients and Type E- Six patients (Figure-7). Most of the injuries were Type- D floating knee injuries and least common type of injury was the Type- B injury. Two patients underwent above knee amputation (both of them were type 3C open fractures of tibia). Follow up duration ranged from 24 months to 89 months (mean was 48 months). Injury severity score ranged from 16 to 45 (mean 16.85).MESS score- 3 in twelve patients. (Table- 13)

4 in ten patients

5 in seven patients

6 in three patients

7 and above in three patients

Three patients had MESS scores of 7 and above, two of these patients underwent above knee amputation (One patient underwent amputation at the level of femoral fracture) and in one patient the fractures were stabilized using external fixators.

Fracture pattern: (Table- 14**)**

Segmental fractures were seen in ten patients (four patients had femur, five patients had tibia and one patient had segmental fractures in both femur and tibia), communited fractures were seen in twenty patients (nine patients with femur, seven patients with tibia and four patients had communition in both femur and tibia) and intra articular fractures were seen in sixteen patients (four patients had femur, eight patients had tibia and four patients had intra articular fractures of both femur and tibia).

Figure 7: Distribution of patients according to LETTS Classification

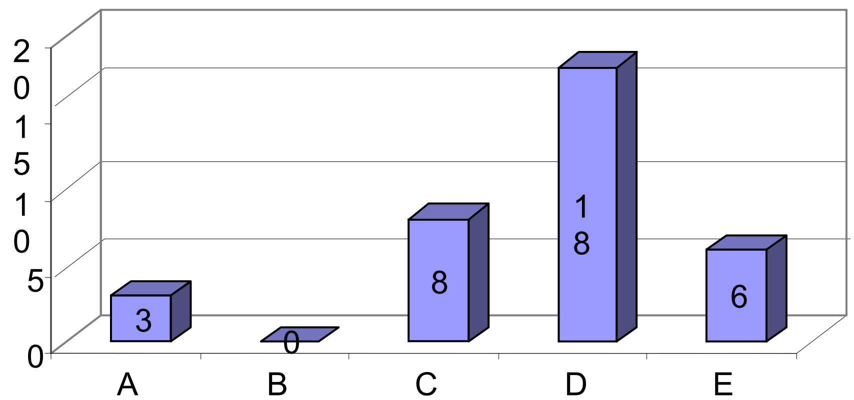


Figure 8: Distribution of Time to surgery

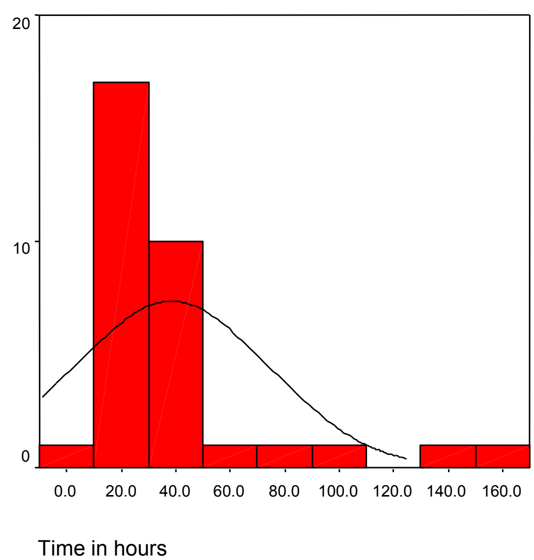


Table 13: Distribution of patients according to MESS Score

MESS Score	No of patients
3	12
4	10
5	7
6	3
7 and above	3

Time to admission:

Time to admission from the time of injury ranged from 1 hour to 23.5 hours at a mean of 4.9 hours.

Time to surgery: (Figure- 8)

The time to surgery from the time of injury ranged from 11 hours to 170 hours, poor by any standard. Surgery was delayed for 5 days in two patients due to other complications like haemothorax in one patient and quadriparesis in other patient. The mean time to surgery was 42.6 hours (after excluding these two patients the mean time to surgery was 30.45 hours), most of the patients were taken up for surgery in between 20 to 40 Hours.

Treatment: (Table- 15**)**

Six patients were treated by nailing of both femur and tibia [one patient had both femoral and tibial closed shaft fractures, two patients had closed femoral shaft and type 2 tibial shaft fractures, two patients had type 3B femoral shaft fractures and closed tibial shaft fractures, one patient had type 3A both femoral and tibial shaft fractures]. Two patients were treated with plate fixation for both femur and tibia [one patient had closed femur fracture and open type 2 tibia fracture, one patient had type 3A open femur fracture and closed tibia fracture]. Two patients had external fixation for both femur and tibia fractures [both had closed tibial fracture and one patient had open type 3A fracture femur and other had open type 3B fracture femur]. Two patients had undergone Ilizarov fixation for the femur and tibial fractures [one patient had both femur and tibia type 3A open fractures with intra articular extension, intraarticular fractures were fixed with cancellous screws, one patient had type 3A femur fracture with intraarticular extension and a closed fracture of the tibia].

Table 14: Distribution of Fracture patterns

Fracture pattern	No of patients	Percentage
Segmental	10	28.6%
Communition	20	57.1%
Intra articular	16	45.7%

Table 15: Distribution of Treatment of Femoral and Tibial fractures

Treatment	No	Type of fracture	Refixation
Both Nails	6	2-Femur-3B, Tibia-closed 2-Femur-Closed, Tibia-2 1-Femur-Closed, Tibia-closed 1-Femur-3A, Tibia-3A	1-Ilizarov
Both plates	2	1-Femur-Closed, Tibia-2 1-Femur-3A, Tibia-Closed	1-Ilizarov
Both Ex fix	2	1-Femur-3A, Tibia-Closed 1-Femur-3B, Tibia-Closed	Nil
Both Ilizarov	2	1-Femur-3A,Tibia-3A 1-Femur-3A, Tibia-Closed	Minimal internal fixation Arthrodesis
F-Nail, T-Plate	3	3-Femur-Closed, Tibia-Closed	1-Ilizarov
F-Nail, T-Ilizarov	2	1-Femur-3A, Tibia-3A 1-Femur-Closed, Tibia-Closed	Nil
F-Nail, T-Screw	3	3-Femur-Closed, Tibia-Closed	Nil
F-K.wire, T-Exfix	1	1-Femur-3B,Tibia-3B	Nil
F- Plate, T-Nail	1	1-Femur-Closed,Tibia-Closed	Nil
F- Plate, T-POP	1	1-Femur-Closed,Tibia-Closed	Nil
F-Plate, T-Nail	1	1-Femur-Closed,Tibia-Closed	Nil
F-Plate , T-Exfix	3	1-Femur-Closed,Tibia-Closed 1-Femur-3A,Tibia-3B 1-Femur-Closed,Tibia-3A	Ilizarov Ilizarov

F-Nail , T-Exfix	6	3-Femur-Closed,Tibia-3B 1-Femur-3A,Tibia-3B 1-Femur-Closed,Tibia-3A 1-Femur-Closed,Tibia-2	2-Ilizarov 1-Plate

Six patients underwent femoral nailing and tibial external fixation and two patients underwent femoral nailing and tibial Ilizarov fixation. Femoral nailing and tibial minimal internal fixation with screws in three patients, K-wire fixation of femur and external fixation of tibia in one patient, femoral plating and tibial external fixation in three patients, femoral plating and tibial intramedullary nailing in two patients and femur plating and Plaster of Paris application of the tibia in one patient.

Refixation: (Table 16)

Ten patients had to have a revision of their tibial fixation, of these eight patients originally had open fractures. For seven of them fixation was done with an Ilizarov fixator. In femoral shaft fractures twenty patients underwent an intramedullary fixation and none of these patients required refixation, only two patients underwent implant removal due to infection. Of these twenty patients with intramedullary nailing, fifteen had closed fractures and five had open fractures (three type 3A and two type 3B), in these four patients had excellent results.

Functional results: (Table 17)

Time to full weight bearing ranged from 4 months to 48 months with a mean of 11.6 months. Range of movements of the knee joint was from 0 degree to 130 degrees with a mean of 98 degrees (two patients with an above knee amputation were excluded). One patient had fixed a flexion deformity of the knee joint of 20 degrees and one patient underwent arthrodesis of the knee joint. Subjective symptoms like knee pain was seen in nineteen patients (54%), knee and ankle pain in two patients, knee and leg pain in two patients, hip pain in two patients, hip pain and ankle pain in one patient. Six patients had an anterior cruciate ligament laxity (17.1%) and two patients had a posterior cruciate ligament laxity (5.7%). The gait was normal in eighteen patients and eleven patients had abnormal gait patterns due to pain.

Table 16: TYPE OF FIXATION AND REFIXATION FOR FEMUR AND TIBIA

Implant	Femur	Refixation	Tibia	Refixation
Nail	20	Nil	7	1-Ilizarov
Plate	8	1-Orthofix	5	2-Ilizarov
Exfix	2	1-Plate 1-Nail	12	4-Ilizarov 1-Plate 1-Ilizarov>Nail 1-Ilizarov>Fibula graft
Ilizarov	2	Nil	4	Nil
K-Wire	1	Nil	Nil	Nil
Amputation	2	--	2	--
Combined	1(Minimal internal fixation& Ilizarov)	Nil	2(1-Screw& Ilizarov,1-Screw & Exfix	Nil
Minimal internal fixation	Nil	Nil	3	Nil

Six patients had permanent restriction of normal gait. Eight patients went back to their original occupation, eight patients had changed their occupation to lighter work, seven patients were able to do only very light work and twelve patients were not able to do any work at all after the injury.

Table 17: Distribution of functional results

Function	Patients	Percentage
Knee Stiffness	16	45.7%
Can squat	17	48.5%
Shortening	10	28.5%

Shortening was seen in ten patients 28.5% (both femur and tibia shortening in two patients, only femoral shortening in four patients and tibial shortening in four patients, two patients with above knee amputation were excluded). Knee stiffness were seen in sixteen patients 48.5% (two patients with amputation were excluded).

Radiological results: (Figure 9)

The time to union of femoral fractures ranged from 5 months to 36 months with a mean of 11.9 months, two femoral fractures had not united. The time to union of tibial fractures ranged from 4 months to 48 months with a mean of 13.3 months (two patients had an above knee amputation and one patient had a non union of tibia these were excluded).

Twenty three patients had delayed union of the fractures. Malunion was seen in fifteen patients 42.8 %(malunion of both bones seen in six patients).

Table 18: Distribution of deformity

Deformity	Number	Percentage
Malunion	15	42.8%
Delayed union	23	65.7%

Complications: (Table 19)

Local Complications were seen in nineteen patients, six patients had wound infection (these includes two patients with MRSA infection, five patients required a wash out after which infection subsided and one patient had the implant removal of the femur). Three patients had a compartment syndrome; all of them underwent a fasciotomy. None of the patients had fat embolism syndrome. Other complications were seen in two patients, one patient had a haemothorax and other had quadriparesis.

Six patients had osteomyelitis, in these four patients had osteomyelitis of the femur, one patient had an osteomyelitis of tibia and one patient had osteomyelitis of both femur and tibia. Two of them had the femoral implant removed, one patient had a sequestrectomy of the tibia and one patient had a sequestrectomy of both the femur and tibia. Four patients had non unions which include two femoral and two tibial non unions.

Figure 9: Distribution of the Time to union

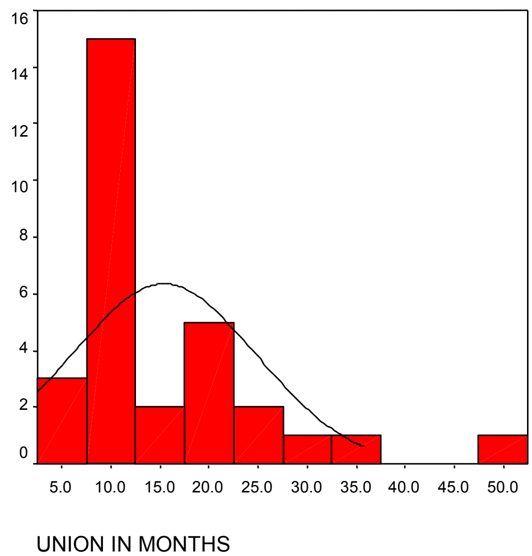


Figure 10: Distribution of Functional results

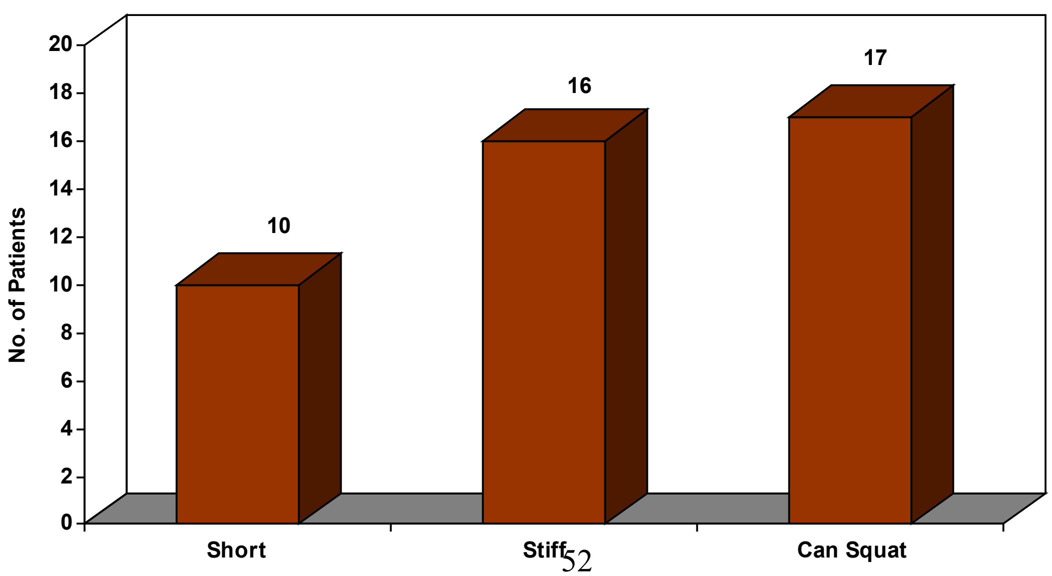


Table 19: Distribution of Complications

Complication	Number	Surgery
Infection * 2 MRSA	* 6	5 Debridement 1-Implant exit
Compartment syndrome	3	Fasciotomy
Non union Femur Tibia	4 2 2	2 Tibia-Ilizarov 1-Femur-orthofix 1-Femur refused
Osteomyelitis Femur Tibia Both	6 4 1 1	2-Femur- Implant exit 1-Tibia-Sequestrectomy 1-Both bones sequestrectomy
Haemothorax	1	Inter costal drinage.
Quadriparesis	1	C2 C3 fusion

Further surgery:

Further surgery was done in nineteen patients, nine patients had bone grafting, five of those patients had bone grafting of both the femur and the tibia, in three patients only a femoral bone grafting was done and one patient underwent a tibial bone grafting.

One patient had primary external fixation of the tibia and followed by refixation with an Ilizarov fixator, and subsequently by open intramedullary nailing was done due to non union. One patient had a primary external fixation of tibia followed by Ilizarov fixator application subsequent Ilizarov fixator removal and fibular grafting (fixed with plate) due to non union (both were open type 3 fractures.). Four tibial fractures that were fixed with an external fixator were later converted to an Ilizarov fixation.

In one patient a tibial external fixation was converted to a plate fixation. In one patient external fixation of both the femur and tibia was converted to an arthrodesis of the knee using an Ilizarov fixator. In one patient who had undergone a femoral plate fixation, was later converted to an orthofix application due to infection. One patient had undergone quadriceps plasty due to knee stiffness.

The functional outcome of the end results were measured using Karlstrom and Olerud criteria for all the thirty five patients. Excellent results were seen in eight patients, Good results in eight patients, fair in seven patients and poor in twelve patients.

Grouping of functional results:

The grouping of the functional results was as follows.

Excellent and Good results were placed in group- 1, Fair and Poor results in Group-2. Group- 1 contained sixteen patients (two Type-A, five Type-C, five Type-D and four Type-E), Group- 2 contains nineteen patients (one Type-A, three Type-C, thirteen Type-D and, two Type-E) and type- D floating knee injuries had poor functional out come.

The functional results were described below. (Table-20, Figure- 11)

Excellent - Eight patients (Two- Type A, Two- Type C, Two-Type D, Two-Type E)

Good - Eight patients (Three- Type C, Three- Type D, Two- Type E).

Fair - Seven patients (One- Type A, Two- Type C, Four- Type D).

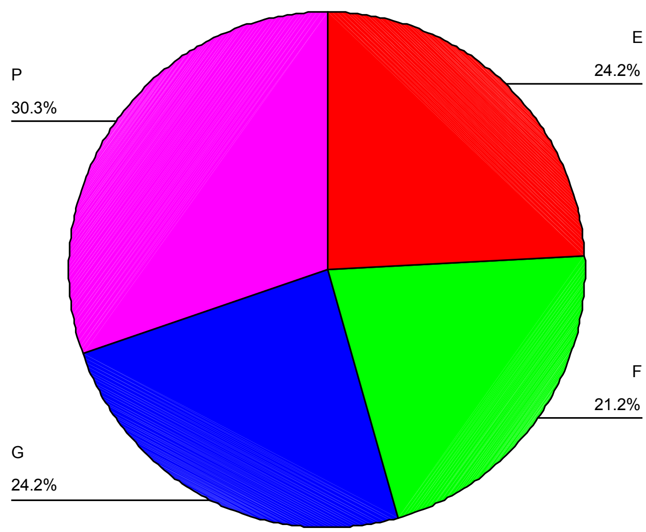
Poor - Twelve patients (One- Type C, Nine- Type D, Two- Type E).

STATISTICS:

The variables that may have affected the final outcome were analyzed. Total seven baseline variables were analyzed they were 1) age of the patient, 2) MESS score, 3) type of fracture (closed or open), 4) time to surgery 5) communited fractures 6) segmental fractures and 7) articular reduction.

Age of the patient and the time to surgery were continious variables. The other variables like fracture type, communition, segmental fractures and articular reduction were categorial baseline variables, these catagorial baseline variables were sub coded to allow sufficient sample size.

Figure 11: Distribution of the functional outcome



E- Excellent, G- Good, F- Fair, P- Poor.

Table 20: Functional results according to LETTS classification

Type	No	Letts type of floating knee injuries				
		A	B	C	D	E
Excellent	8	2	0	2	2	2
Good	8	0	0	3	3	2
Fair	7	1	0	2	4	0
Poor	12	0	0	1	9	2

Coding system:

Type of fractures were sub divided as follows, 0- for closed fractures, 1- for type 1 open and type 2 open fractures, 2- type 3 open fractures. Communited fractures were sub divided as 0- for no communition, 1- for presence of Communition in one or both bones. Segmental fractures were sub divided as 0- for absence of segmental fractures and 1- for segmental fracture present in one or both bones. Articular reduction was sub divided as 0- for good articular reduction and 1- for bad articular reduction. MESS Scores were sub divided in to 1- for MESS scores less than three and 2- for scores of four and above.

The final outcome measures of this study were, 1) Knee stiffness 2) Malunion of fractures 3) Shortening of the involved limb and 4) Time to union of fractures. For all the outcome measures unadjusted, the relative risk was estimated for the seven baseline variables. Knee stiffness, malunion and shortening were binomial hence logistic regression models were used to derive the predictive models. Independent sample T- test and Pearson correlation Chi Square tests were used to analyze the predictors.

In this analysis of thirty five patients, thirty three patients were analyzed statistically and two patients those had undergone an above knee amputation were excluded from the analysis. If the p value is less than 0.05 the variables were statistically significant. The analysis is described below.

A) **Stiffness and communition** (Table- 21)

Communited fractures were seen in eighteen patients, fourteen of these patients had knee stiffness and four patients did not have knee stiffness. No communition was seen in fifteen patients, of these only two patients had knee stiffness at follow up. For knee stiffness, communition was a significant variable p= 0.000 (two patients with an above knee amputation are excluded).

B) **Stiffness and segmental fractures** (Table- 22)

Segmental fractures were seen in ten patients, in these seven patients had knee stiffness and three patients did not have knee stiffness. Segmental fractures were not seen in twenty three patients, in these fourteen patients did not have knee stiffness and nine patients had knee stiffness (p= 0.103). Segmental fractures were statistically not significant in relation to knee stiffness (p= 0.103)

C) Stiffness and MESS score (Table- 23)

MESS score of more than 4 was seen in twenty one patients, of these twelve patients had knee stiffness and nine patients did not have knee stiffness. MESS score of less than 3 was seen in twelve patients, of these eight patients did not have knee stiffness and four patients had knee stiffness. The MESS score was not statistically significant for knee stiffness (p= 0.188).

Table 21: STIFFNESS AND COMMUNITION

Communition	**Stiffness**		**Total**
	0-Absent	**1-Present**	
0-Absent	13	2	15
1-Present	4	14	18
Total	17	16	33

Table 22: STIFFNESS AND SEGMENTAL FRACTURES

Segmental Fracture	Stiffness		Total
	0-Absent	1-Present	
0-Absent	14	9	23
1-Present	3	7	10
Total	17	16	33

MESS Score	Stiffness		Total
	0-Absent	1-Present	
1	8	4	12
2	9	12	21
Total	17	16	33

Fracture type	Stiffness		Total
	0-Absent	1-Present	
0	8	3	11
1	2	2	4
2	7	11	18
Total	17	16	33

Table 23: STIFFNESS AND MESS SCORE

Table 24: STIFFNESS AND FRACTURE TYPE

Table 25: STIFFNESS AND ARTICULAR REDUCTION

Articular reduction	Stiffness		Total
	0-Absent	1-Present	
0	15	6	21
1	2	10	12
Total	17	16	33

D) Stiffness and fracture type: (Table- 24)

Eighteen patients had type 3 open fractures, of these eleven patients had knee stiffness and seven patients did not have knee stiffness. Four patients had type 1 or type 2 open fractures, of these two patients had knee stiffness and two patients did not have knee stiffness. Eleven patients had closed fractures, of these eight patients did not have knee stiffness and three patients had knee stiffness. The p= 0.209; hence the fracture type is statistically not significant for knee stiffness.

E) Stiffness and articular reduction: (Table- 25)

Twenty one patients had good articular reduction, six of them had knee stiffness and fifteen patients did not have knee stiffness. In twelve patients the articular reduction was inadequate (step more than 5 mm) in these ten patients had knee stiffness and two patients did not have knee stiffness. The p= 0.002; hence the poor articular reduction is statistically significant for knee stiffness.

F) Stiffness and age; (Table- 26)

The mean age of patients who had knee stiffness was 37.47 years and those with out knee stiffness were 29.82 years. The p= 0.045; hence the increasing age was statistically significant for knee stiffness.

G) Stiffness and time to surgery: (Table- 26)

The mean time to surgery of patients who had knee stiffness was 40.38 hours and those with out knee stiffness were 36.76 hours. The p= 0.056; hence the time to surgery is a statistically not significant for knee stiffness.

Table 26: Distribution of Knee Stiffness and other variables

Variables	CHI-Square value	p value
Communition	13.604	0.000
Segmental	2.659	0.103
MESS score	1.733	0.188
Fracture type	3.134	0.209
Articular reduction	9.169	0.002
Age		0.045
Time to surgery		0.056

In KNEE STIFFNESS (Table- 26) –1) Communited fractures (p= 0.000), poor articular reduction of fractures (p= 0.002) and increasing age (p= 0.045) were statistically significant variables of stiffness.

2) Segmental fractures, MESS score, fracture type and time to surgery were statistically not significant variables of stiffness (all have p > 0.050).

MALUNION:

A) Malunion and communition: (Table- 27)

Eighteen patients had communited fractures, thirteen of them went on to malunion and five patients did not have malunion. Fifteen patients had non communited fractures, of these only one patient had a malunion. The p= 0.000, hence comminuted fractures are a statistically significant for malunion (p= 0.000).

B) Malunion and segmental fractures: (Table- 28)

Ten patients had segmental fractures, six of them had malunion and four patients did not have a malunion. Twenty three patients did not have segmental fractures. But 8 of these patients had malunions. The segmental fractures were statistically not significant for malunion, (p= 0.178).

C) Malunion and MESS score: (Table- 29)

MESS score of more than 4 was seen in twenty one patients, eleven of them had malunion and ten of them did not have malunion. MESS score of less than 3 was seen in twelve patients, nine of them did not have malunion and three of them had malunions. The MESS score was statistically not significant (p= 0.126).

Table 27: MALUNION AND COMMUNITION

Communition	Malunion		Total
	0-Absent	1-Present	
0-Absent	14	1	15
1-Present	5	13	18
Total	19	14	33

Table 28: MALUNION AND SEGMENTAL FRACTURES

Segmental Fractures	Malunion		Total
	0-Absent	1-Present	
0-Absent	15	8	23
1-Present	4	6	10
Tptal	19	14	33

Table 29: MALUNION AND MESS SCORE

MESS Score	Mal union		Total
	0-Absent	1-Present	
	9	3	12
2	10	11	21
Total	19	14	33

Articular reduction	Malunion		total
	0-Absent	1-Present	
0-Good	15	6	21
1-Poor	4	8	12
Total	19	14	33

Table 30: MALUNION AND FRACTURE TYPE

Table 31: MALUNION AND ARTICULAR REDUCTION

D) Malunion and type of fracture: (Table- 30)

Eighteen patients had type- 3 open fractures, nine of them had malunions and nine of them did not have malunion. Four patients had type- 1 or type- 2 fractures, one of

Fracture type	Malunion		Total
	0-Absent	1-Present	
0	7	4	11
1	3	1	4
2	9	9	18
Total	19	14	33

these had malunion and three of them did not have malunion. Eleven patients had closed fractures, seven of them did not have malunion and four of them had malunions. The type of fractures were statistically not significant for malunion (p= 0.581).

E) Malunion and articular reduction: (Table- 31)

Twenty one patients had good articular reduction, six of them had malunions. Twelve patients had a poor reduction of the articular surface, eight of them had malunions. Poor articular reduction was statistically significant for malunion (p= 0.033).

F) Malunion and age: (Table- 32)

The mean age of the patients with malunion was 36.71 and that with out malunion was 30.83. The age of the patient was statistically not significant for malunion (p= 0.131).

G) Malunion and time to surgery: (Table- 32)

The mean time to surgery for patients who had malunion was 42.14 hours and with out malunion was 35.84 hours. The time to surgery was statistically not significant for malunion (p= 0.625).

In **MALUNION** (Table- 32) -1) The communited fractures (p= 0.000) and poor articular reductions (p= 0.033) were statistically significant for malunion (p < 0.05).

2) Segmental fractures, MESS score, type of fracture, age of the patient and time to surgery were not statistically significant for malunion (p > 0.05).

Table 32: Distribution of Malunion and other variables

Variables	CHI-Square value	p value
Communition	14.395	0.000
Segmental	1.815	0.178
MESS score	2.344	0.126
Fracture type	1.086	0.581
Articular reduction	4.537	0.033
Age		0.131
Time to surgery		0.625

SHORTENING:

A) Shortening and communition: (Table- 33)

Eighteen patients had communited fractures, nine of these had shortening. Fifteen patients had no communition, only one patient had shortening. Communited fractures were statistically significant for shortening (p= 0.007).

B) Shortening and segmental fractures: (Table- 34)

Ten patients had segmental fractures, four of these had shortening. Twenty three patients had non segmental fractures, of these six patients had shortening. Segmental fractures were statistically not significant for shortening (p= 0.424).

C) Shortening and MESS score: (Table- 35)

Twenty one patients had a MESS score of more than 4; eight of these patients had shortening. In twelve patients the MESS score was less than 3 and two of them had shortening. The MESS score was statistically not significant for shortening the, p= 0.198.

D) Shortening and fracture type (Table- 36)

Eighteen patients had type 3 open fractures, eleven of these had shortening. Four patients had open type 1 or type 2 fractures and only one patient had shortening. Fracture type was statistically not significant for shortening as p= 0.485.

E) Shortening and age: (Table- 38)

Shortening was seen with age group with a mean of 35 years. The mean age of those who did not have shortening was 32.78. Age when compared against shortening was found to be not significant (p= 0.612).

Table 33: SHORTENING AND COMMUNITION

Communition	Shortening		Total
	0-Absent	1-Present	
0-Absent	14	1	15
1-Present	9	9	18
Total	23	10	33

Table 34: SHORTENING AND SEGMENTAL FRACTURES

Segmental fractures	Shortening		Total
	0-Absent	1-Present	
0-Absent	17	6	23
1-Present	6	4	10
Total	23	10	33

Table 35: SHORTENING AND MESS SCORE

MESS score	Shortening		Total
	0-Absent	1-Present	
1	10	2	12
2	13	8	21
Total	23	10	33

Table 36: SHORTENING AND FRACTURE TYPE

Fracture type	Shortening		Total
	0-Absent	1-Present	
0	9	2	11
1	3	1	4
2	11	7	18
Total	23	10	33

Table 37: SHORTENING AND ARTICULAR REDUCTION

Articular reduction	Shortening		Total
	0-Absent	1-Present	
0-Good	17	4	21
1-Poor	6	6	12
Total	23	10	33

F) Shortening and articular reduction: (Table- 37)

Twenty one patients had good articular reductions, of these four patients had shortening. Poor articular reduction was seen in twelve patients, six of them had shortening. Articular reduction of fractures was statistically not significant as a variable for shortening, p= 0.063.

G) Shortening and time to surgery :(Table- 38)

Shortening of 1 cm to 4 cms was seen in ten patients with a mean time taken to surgery of 45.8 hours. No shortening was seen in twenty three patients, who were taken up for surgery at a mean time of 35.35 hours. Time to surgery variable was found to be not significant, p= 0.677.

In **SHORTENING** (Table- 38) - 1) Communited fractures were statistically significant as a variable for shortening, p= 0.007.

2) Segmental fractures, MESS score, fracture type, age of the patient and poor articular reduction were statistically not significant because p> 0.05.

TIME TO UNION (Table- 39)

1) Communited fractures (p= 0.019), segmental fractures (p= 0.031), increase in MESS score (p= 0.033), open fractures (p=0.035) were statistically significant variables for delayed time to union.

2) Articular reduction, age of the patient and time to surgery were not significant (Since the p > 0.05).

Table 38: Distribution of variables and Shortening

Variables	CHI-Square value	p value
Communition	7.274	0.007
Segmental	0.639	0.424
MESS score	1.660	0.198
Fracture type	1.447	0.485
Articular reduction	3.464	0.063
Age		0.612
Time to surgery		0.677

Table 39: Distribution of variables and Time to union

Variables	95%confidence interval		p value
	Lower	upper	
Communition	1.384	14.349	0.019
Segmental	1.06	18.919	0.031
MESS score	-12.748	0.572	0.033
Fracture type open 1,2	0.298	13.883	0.042
Fracture type open -3	0.335	13.647	0.035
Articular reduction	-2.528	11.886	0.194
Age			0.812
Time to surgery			0.556

Infection and knee stiffness (Table- 40)

Infection was seen in twelve patients, six of these had wound infection and six of them had osteomyelitis. Knee stiffness was seen in eighteen patients, eight of them had infection. Knee stiffness absent in seventeen patients, four of them had infection. The p= 0.160; hence the infection was statistically not significant.

Table 40: Distribution of Infection and knee stiffness

Knee stiffness	Infection		
	Absent	Present	Total
Absent	13	4	17
Present	8	8	18
Total	23	12	35

Infection and time to surgery:

The mean time to surgery for patients who had infection was 51.04 hours and with out infection was 38.22 hours (mean time 10 hours less). Time to surgery in relation to infection was statistically not significant (p=0.308).

DISCUSSION

Floating knee injuries are ipsilateral fractures of femur and tibia which include femoral fractures from the sub trochanteric level to the distal condyles and tibial condyles and shaft fractures. These are usually high velocity injuries sustained by a motor vehicle accident. They are often associated with other system injuries and with injuries to the contra lateral lower limb. All patients in this study were resuscitated in the emergency department. Open fractures were given primary wound toileting in the Emergency Department. The patients were taken to the operating room where a thorough debridement of the wound was done followed by definitive stabilization of the fractures.

This study was carried out at Christian Medical College and Hospital, Vellore. This is a teaching hospital and a tertiary referral center. The hospital is also located near the Chennai- Bangalore highway and hence admits patients involved in high velocity motor vehicle accidents under its care. The study was done retrospectively over a period of 4 years. The last patient included in the study was treated in December 2003. The minimum follow up after surgical treatment was 2 years.

Twenty four patients were in the age group of 30 to 40 years and the age group ranged from 5 years to 55 years, average age was 34.5, Hee et al in his study of eighty nine patients, also described the same age group[13].

In this study there was a male preponderance (94% males, 6% female). Majority of the other studies in literature also describes the similar gender distribution (Karlstrom et al [15] and Fraser et al [10]).

The most common mode of injury was that of high velocity motor vehicle accident (97%), seventeen patients had a two wheeler versus a four wheeler collision and in twenty two patients two wheelers were involved in the accident (three patients two wheeler versus pedestrian and two patients two wheeler versus two wheeler). We attribute this to the fact that our hospital is situated on a major highway and is a tertiary referral center. Twenty three patients had right sided injury and twelve patients had left sided injury.

Twenty two patients had fourty six associated injuries and eighteen (51.4%) of them had ipsilateral injuries (fracture patella was seen in seven (20%) patients). Three patients (8.5%) had an associated vascular injury, two of them underwent an above knee amputation and the third patient underwent thrombectomy and stabilization fractures with an external fixator. There were four patients with contralateral lower limb injuries, two had tibial and two had open tibial fractures. Other system injuries were seen in twelve patients who included three patients with clavicle fractures and two patients with rib fractures. Anterior Cruciate Ligament laxity was seen in six patients (17.1%) and Posterior Cruciate Ligament laxity was seen in two (5.7%) patients. The incidence of associated ligamentous injuries varies from 2- 39% (Schiedts et al [25]), of the eight patients with ligamentous laxity, four of them had poor results, two of them had fair results and two had good results.

Letts classification was used in this study to categorize the patients who were surgically treated. Type- D injury is the most common type of floating knee injury seen in this study (similar results are reported by Hee et al in 2001 [13]). Open fractures were classified using the Gustilo Anderson system, twenty four patients (68.5%) had open fractures and eleven patients (31.4%) had closed fractures. Among these there were more open tibial fractures than open femoral fractures (femur-twelve, tibia-seventeen).

Segmental fractures were seen in ten patients (28.5%) and communited fractures were seen in twenty patients (57.1%). sixteen patients(45.7%) had intra articular fractures (Fraser et al [10] and Bansal et al [3] described that the functional outcome was poor in the presence of intra articular fractures). Hee et al described that comminuted and segmental fractures were poor predictors of functional outcome[13].

Three patients had MESS scores of 7 and above, in these two patients had an above knee amputation. The MESS scores for other patients were 3 in twelve patients, 4 in ten patients, 5 in seven patients and 6 in three patients. Twenty two patients in this study had MESS scores of 3 or 4 (62.5%).

In this study most of the patients had skeletal injuries in the limb alone and the Injury Severity Scores ranged from 16 to 45 at a mean of 16.85, only two patients had scores of 45 each and all others had scores of 16.

All the patients in this study were admitted in the Emergency Department with in 24 hours after the injury, ranging from one hour to 23.5 hours at an average of 4.9 hours. The time to surgery after the injury ranged from 11 hours to 170 hours, two of them had closed fractures of both femur and tibia and surgery was delayed for 5 days, one because of very unstable condition resulting from hypovolemia and haemothorax. And the second patient surgery was delayed again due to an unstable condition and quadriparesis resulting from C1 C2 fracture (C1, C2 fixation done later as first surgery). The average time to surgery was 42.6 hours (after excluding these two patients the mean time to surgery was 30.45 hours), seventeen patients in this study had undergone surgery in 20 to 40 hours (seven patients less than 20 hours, eleven patients more than 40 hours).

Only few studies in literature were available regarding specific treatment for these injuries. Initially non operative management is described in literature (Ul Haque et al in 1983 [26]) and with advances of various techniques operative treatment (internal fixation) was an essential component in the management of these injuries. Both femoral and tibial fractures should be rigidly fixed (Enders nail by Katada et al 1984 [16]). In 1986 Letts et al described that at least one fracture should be rigidly fixed either internally or externally usually the femur[17]. Femoral fixation and non operative management for associated ipsilateral tibial fractures by Plaster of Paris was described by Bansal et al in 1984[3]. Flexible intramedullary nails were described by Behr et al in 1987 [4]. Soft tissue sparing surgery like percutaneous plating was described by Lobenhoffer et al in 1996[18]. Single incision nailing of both tibia and femur was described by Rethnam et al in 2006[23].

In this study twenty femoral fractures were stabilized using an intramedullary nail, these include five open fractures (four patients had excellent or good results and one patient had a poor result), only one patient had the implant removed due to infection. Seven tibial shaft fractures were fixed with intramedullary nails, of this seven, one patient required refixation with an Ilizarov fixator. Three patients had excellent results and one patient had good result, other three patients had poor or fair result. Intra medullary fixation is the preferred method of fixation in both femoral and tibial diaphyseal fractures as described by Dwyer et al 2005 [9]. Tibial fractures had more complications than femoral fractures, ten tibial fractures underwent repeat fixation, seven of these patients underwent Ilizarov fixation. Only one of these had a satisfactory result, the other patients had a poor result. Ilizarov fixation appears to be a better option in open diaphyseal fractures of tibia. Intraarticular fractures were fixed with minimal internal fixation by cancellous screws or plating which was augmented with or without Ilizarov fixator. The mean time to union for femoral fractures was 11.9 months, and for tibial fractures was 13.3 months. The overall the time to union was 12.6 months. Hence tibial fractures took a longer time to unite than femoral fractures.

Repeat surgeries were necessary in eighteen patients (51.4%). Higher than other studies, bone grafting was the most common of all subsequent surgeries (nine patients). Revision of fixation had been performed in thirteen patients, revision of fixation of the tibia was the most frequent of them (ten patients underwent refixation, eight of them had open tibial fractures and seven out of the eight open tibial fractures had undergone revision to Ilizarov fixation). Fraser et al showed subsequent surgeries were required in 35 % of patients [10].

Local complications (Table- 41) like the wound infection were seen in six patients (17.1%). Osteomyelitis in six patients (17.1%), Osteomyelitis of the femur was more common (four patients). Non union was seen in four patients (11%). These were two tibial and two femoral nonunions, the two tibial nonunions were treated by an Ilizarov fixation and one femoral nonunion treated with an Orthofix application. The other patient with the femoral nonunion refused surgical treatment. Compartment syndrome was seen in three patients (8%). A fasciotomy was done for all these patients (table 36). Fraser described 30% infection in his series of two hundred and twenty two patients [10].

One patient had a haemothorax due to multiple rib fractures and one patient had quadriparesis due to cervical spine injury (5%). None of the patients in this study showed fat embolism syndrome, Schiedts et al described fat embolism syndrome in 12% of patients in his series [25].

All the patients in this study were followed up. The follow up was a minimum 24 months in all cases. The mean was 48.1 months (range 24 to 89 months). Time to full weight bearing ranged from 4 months to 48 months with a mean of 11.6 months.

Table 41: Distribution of Complications

Complication	**Number**	**Surgery**
Infection * 2 MRSA	* 6	5 Debridement 1-Implant exit
Compartment syndrome	3	Fasciotomy
Non union Femur Tibia	4 2 2	2 Tibia-Ilizarov 1- Femur-orthofix 1- Femur refused repeat surgery
Osteomyelitis Femur Tibia Both	6 4 1 1	2- Femur- Implant exit 1- Tibia-Sequestrectomy 1- Both sequestrectomy
Haemothorax	1	Inter costal drinage.
Quadriparesis	1	C2 C3 fusion

Table 42: Distribution of Functional outcome

Function	Patients	Percentage
Shortening	10	28.5%
Stiffness	16	45.7%
Can do squatting.	17	48.5%

Hee et al described full weight bearing of these types of injuries at a mean of 6.5 months[13].

Knee pain was the most common symptom which was seen in nineteen patients (54%). Fraser et al in his study of two hundred and twenty two patients described knee pain in 50% of patients [10]. The gait was normal in eighteen patients (51.4%). Hee et al in his study of eighty nine patients described knee stiffness in 29% of patients[13], shortening was seen in 21% of patients and the incidence of knee stiffness was 45.7% (sixteen patients). Seventeen (48.5%) patients can squat on the floor.

The time to union of femoral fractures ranged from 5 months to 36 months with a mean of 11.9 months, overall the mean time to union of fractures was 12.6 months. Two femoral fractures had not united. The time to union of tibial fractures ranged from 4 months to 48 months with a mean of 13.3 months (two patients had an above knee amputation and these were excluded). Hee et al reported the time to union at a mean of 12 months[13].

Malunion of fractures was seen in fifteen patients (42.5%). Hee et al described malunion in 19% and twenty four patients (68%) had delayed union, in these one patient had non union of the femur and one patient had non union of both the femur and tibia[13]. Hee et al described 67.4% of delayed union in his series[13].

Statistical outcome analysis

Four out come measures were analyzed with seven baseline variables statistically. The four outcome measures were.

1) Knee stiffness.
2) Malunion.
3) Shortening.
4) Time to union.

And the seven baseline variables were.

1) Age of the patient
2) MESS score after admission to the Emergency Department.

3) Time to surgery after injury.

4) Type of the fracture (open or closed).

5) Presence of Communition.

6) Segmental fractures.

7) Articular reduction.

All the baseline variables and outcome measures were sub coded to allow sufficient sample size. The type of fractures was sub divided in to 0- for closed fractures, 1- for type 1 open and type 2 open fractures, 2- for type 3 open fractures. Communited fractures were sub divided in to 0- for no communition, 1- for Communition present in one or both bones. Segmental fractures were sub divided in to 0- for no segmental fractures 1- for segmental fracture present in one or both bones. Articular reduction was sub divided in to 0- for good articular reduction and 1- for bad articular reduction. MESS Scores were sub divided in to 1- for MESS scores less than three and 2- for scores four and above. The summary of the analysis is described below.

1) KNEE STIFFNESS:

The seven base line variables were correlated with knee stiffness using the Chi square test. It was found out that the communited fractures were highly significant variable for the knee stiffness ($p = 0.000$). The poor articular reduction was also a significant variable for the knee stiffness ($p = 0.002$); the increase in age of the patient had a significant correlation with the increased knee stiffness as the $p = 0.045$. And all the other variables like MESS score ($p = 0.188$), time to surgery ($p = 0.056$), type of fractures ($p = 0.209$), segmental fractures ($p = 0.103$) were not significant variables for knee stiffness ($p > 0.050$). Summarising the above shows

A) Older patients are more prone for knee stiffness.

B) Communited fractures are more prone for knee stiffness.

C) Poor articular reduction is more prone for knee stiffness.

2) MALUNION:

The communited fractures and poor articular reduction correlated significantly with malunion of fractures (p =0.000 and 0.033). The age of the patient (p= 0.131), segmental fractures (p= 0.178), type of fracture (p= 0.581), time to surgery (p= 0.625) and the MESS scores (p= 0.126) were statistically not significant (p > 0.05).

3) SHORTENING:

Communited fractures were a statistically significant variable for shortening (p =0.007) and all the other variables like segmental fractures (p= 0.424), MESS score (p= 0.198), fracture type (p= 0.485), articular reduction (p= 0.063), age of the patient (p= 0.612) and time to surgery (p= 0.677) were not statistically significant (p > 0.05).

4) TIME TO UNION:

The MESS scores of 4 and above (p= 0.033) and communited fractures (p= 0.019), segmental fractures (p= 0.031) and open fractures (type-1 and 2- p= 0.042, open type 3 p= 0.033) were statistically significant variable for delayed time to union. The age of the patient, time to surgery and poor articular reduction were statistically not significant when analyzed as a variable for time to union (p > 0.05). The statistical analysis shows delayed union of fractures was seen to be statistically significant (p < 0.05) in,

A) A MESS scores of more than 4

B) Open fractures on arrival

C) Communited fractures and

D) Segmental fractures

In Summary communited fractures were a statistically significant variable for all the four outcome measures knee stiffness, malunion, shortening and time to union. The poor articular reduction was a significant variable for knee stiffness and malunion. All the other five variables were significant variables for only one outcome measure.

Table 43: COMPARISON OF THIS STUDY WITH OTHER STUDIES

Name of study	Patients	Excellent	Good	Fair	Poor
Fraser et al 1978	63	3	15	30	15
Schiedts et al 1994	18	4	7	-	7
Hee et al 2001	89	6	53	25	4
This study 2006	35	8	8	7	12

Excellent results:

In this study eight (22.8%) patients had excellent results, among these eight patients said their end results were excellent, none of the patients had pain with normal activity. None of the patients had gait abnormality or limping, all the patients returned to their original occupation. All of the patients had full range of movements at the knee joint (all had knee range of motion of more than 100 degrees and all patients were able to squat. In the earlier non operative era, excellent results were less than 20% (Fraser et [10]al, Schiedts et al [25]).

In subsequent studies with operative treatment becoming the mainstay of management in these injuries, the number of patients with excellent results were low due to multiple factors such as nature of the injury and fracture pattern etc.. In this study 22.5% (eight) patients had excellent results as compared to 6.5% of excellent results with Hee et al [13].

Good results:

In this study eight (22.8%) patients had good results, all the eight patients had knee pain and all of them had knee range of movements more than 100 degrees except one patient who had knee range of motion up to 100 degrees. Two patients had shortening of less than 1 cm. All except two of patients had normal walking ability. These two patients had a minimal limp. All the patients returned to a less stressful occupation compared to their occupation prior to injury. One patient had a posterior cruciate ligament laxity. All the patients except one were able to squat on the floor, this patients knee range of motion was 100 degree. None of the patients had hip pain or ankle pain. Hee et al reported 59.5% of good results as compared to our study[13].

Fair results:

Among the seven (20%) patients who had fair end results, four patients were type-D floating knee injuries, all had some amount of knee pain, ankle pain and hip pain. All the patients were unable to squat and all the patients had knee range of motion less than 100 degrees (80 to 90 degrees). Malunion was seen in all the patients, anterior cruciate ligament laxity was seen in two patients, antalgic gait pattern was seen in four patients. Shortening was seen in two patients (1- 3 cm shortening). All the patients limited their work to very minimal or changed to a much lighter job. Hee et al reported 28% of patients with Fair results[13].

Poor Results:

Poor results were seen in twelve (34.2%) patients, nine of them had type – D floating knee injuries. All the twelve patients did not return to work and all these patients were unable to squat on the floor. The knee range of motion of all the patients were less than 100 degrees, two of these patients had undergone above knee amputation, one patient underwent a knee arthrodesis and one patient had a nonunion of femur. Three patients had symptomatic anterior cruciate ligament laxity and one patient had posterior cruciate ligament laxity. All the patients had restricted walking ability, six of them walked with crutches, eight patients had shortening (all of which was more than 2cm) and eight patients had malunion of more than 20 degrees. Hee et al [13] reported only 4% of patients with poor results.

When compared to other studies (Table 43) this study shows an increase in the number of poor results. One of the causative factors may be a significant delay between seeing the patient and carrying out operative treatment. None of these patients were taken up for surgery within the golden six hour period after injury. The mean time before operation was 42.6 hours. The results of this series of operated patients compares badly even when compared to the studies reported in era prior to operative treatment.

In the excellent group the time to surgery was 40.12 hours (one patient with 149 hours)

Good group- 44.68 hours

Fair group- 58.35 hours (one patient with 170 hours)

Poor group- 33.7 hours

Statistically the time to surgery was not significant, this again because the time to surgery was increased in all the patients. Infact one can also look at it the other way and say that inspite of such inordinate delays in taking the patients up for surgery a fair proportion got away without infection and stiffness. It can also be looked at and said that when all cases are delayed, analysis of the significance becomes a complex issue. Eight of thirty five patients had a good result.

The study of two hundred and twenty two patients by Fraser et al in 1978 reported that 35% of patients required further surgery for delayed union or nonunion, osteomyelitis, refracture and malunion, regardless of the treatment group. A disturbing factor was the 30% incidence of osteomyelitis in patients treated by fixation of both fractures, almost three times the incidence when only one fracture was fixed. A 30% incidence of delayed union or nonunion occurred in patients managed nonoperatively. Of sixty three patients personally examined, the worst results found were those following conservative management of both fractures. More use of rigid external fixation and of cast bracing is recommended in the management of the fractured tibia, combined with internal fixation of the femoral fractures. Examination of the knee suggested that with ipsilateral fractures, disruption of ligaments is a common occurrence and one should always have a high index of suspicion in these cases.

Schiedts et al in 1994 in his study of twenty four patients reported clinical evidence of fat embolism after reaming of femoral shaft fractures in three patients. Reaming led to increase in pulmonary artery pressure and increase in pulmonary free fatty acids. Ipsilateral femoral and tibial nailing showed increased shortening and rotational malunion. This could be reduced by interlocking nails. Knee effusion in these patients indicated meniscal, articular or ligament pathology and it could lead to a poor result.

Hee et al (2001) in his study of eighty nine patients, reported predictors of outcome in floating knee injuries, they are an increase in age, an increasing in number of pack years smoked at the time of injury, Injury Severity Score, open fractures, segmental fractures and communited fractures.

CONCLUSION

Floating knee injuries are due to high velocity motor vehicle accident in which a two wheeler versus a four wheeler is the commonest. Type D injuries are the most frequent type of injury. Men are affected more than women. The right side injury is more frequent than the left side. 17.1% of patients had associated anterior cruciate ligament injuries and 5.7% of patients had posterior cruciate ligament injuries. 45.6% of patients in this study had an excellent and good functional outcome and 54.4% of patients had a fair or poor functional outcome. Type D injuries had poorer functional outcome.

Local complications like wound infection seen in 17.1% of patients and osteomyelitis seen 17.1% of patients. A communited fracture is the most common predictor affecting the functional outcomes like knee stiffness, shortening, and time to union. The other predictors affecting the functional outcomes are poor articular reduction, open fractures, segmental fractures, older age and MESS scores above 4. The time to union of tibia is more than that of femur. Revision fixation for tibial fractures was more frequent than femoral fractures.

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PROFORMA

Name Age/ Gender

Hospital No MRD No

Address Weight

Velocity of injury

High	Low

Side of injury

Right	Left

Time of injury
Time of admission in Emergency department
Date of injury
Date of admission
ISS
Date of discharge

DIAGNOSIS- 1) FEMUR—(Closed-Tscherne 0, 1, 2, 3)

0	1	2	3

Open Gustilo- Anderson I, II, III

I	II	III-A	III-B	III-C

AO Classification
Level of injury

Proximal	Middle	Distal

Fracture pattern

Intraarticular	Communited	Bone loss

Treatment

Nail	Plate	Exfix	Ilizarov

Number of surgeries

S. NO	Surgery	Date

Time of union:
Malunion:

Valgus	Varus	Anteroposterior	Rotation

Shortening:
Infection:

Superficial	Deep

DIAGNOSIS- 1) TIBIA—(Closed-Tscherne 0, 1, 2, 3)

0	1	2	3

Open Gustilo- Anderson I, II, III

I	II	III- A	III- B	III- C

AO Classification:
Level of injury:

Proximal	Middle	Distal

Fracture pattern:

Intraarticular	Communited	Bone loss

Treatment:

Nail	Plate	Exfix	Ilizarov

Number of surgeries:

S. NO	Surgery	Date

Time of union:
Malunion:

Valgus	Varus	Anteroposterior	Rotation

Shortening:
Infection:

Superficial	Deep

Ligamentous injury:

EXAM	ACL	PCL	MCL	LCL
Casualty				
Post op				
Follow up				

Meniscal injury:

Medial	Lateral

Neurological injury:

Yes	No

Vascular injury:

Yes	No

Smoking

Yes	No

Complication

Local	General

Time of Partial weight bearing:
Time to Full weight bearing:
Time to Radiological union:

PHYSICAL EXAMINATION

Follow up in months
Date
Gait
Walking aid

	Duration	Community	Steps	Public	Sit/Squat

Subjective symptoms:

Pain	Limp	Effusion	Deformity	Infection	Instability	Others

Range of movements:
1) Hip

	Flexion	Extension
Active		
Passive		

2) Knee:

Flexion	Flexion	Extension
Passsive		
Active		
Patella glide		

3) Ankle:

	Dorsiflexion	Plantar flexion
Active		
Passive		

4) Knee stiffness:

Intraarticular	Extraarticular	Combined

Ligamentous laxity:

MCL	LCL	ACL	PCL	Combined

Shortening:

Femur	Tibia

Deformity:

	Valgus	Varus	AP	Rotatory
Femur				
Tibia				

Socioeconomic status

Pre injury	Post treatment

Occupation:

Pre injury	Post treatment

Implant removal:

Femur	Tibia

Clinical photograph:

Yes	No

X- Ray- Femur:

Union	Consolidation	Implant	ARTRed	Valgus	Varus	AP	Infection

X- Ray- Tibia

Union	Consolidation	Implant	ARTRed	Valgus	Varus	AP	Infection

Assessment of end results (Karlstrom and Olerud):

Excellent	Good	Fair	Poor

Key to Master Chart

A) Age.

B) Sex.

C) Injury Severity Score.

D) Associated injuries.-0- None

1- Head and neck

2- Face

3- Upper limb/ clavicle

4- Chest

5- Abdomen/pelvis

6- Pelvis

7- Contralateral lower limb

8- Dorsal and lumbar spine

E) Type of fracture-0) Closed, 1) Type-1, 2) Type-2, 3) Type-3A, 3B, 3C

F) Segmental fractures-0) - None, 1) - One bone, 2) - Both bones

G) Intraarticular fractures-0) - None, 1) - One bone, 2) - Both bones

H) Communited fractures- 0) - None 1) One bone, 2) Both bones

I) Tibial treatment-1)- Nail, 2)- Plate, 3)- Exfix, 4)- Ilizarov, 5)- Screws, 6)- Orthofix.

J) Femoral treatment-1)- Nail, 2)- Plate, 3)- Exfix, 4)- Ilizarov, 5)- Screws, 6)- Orthofix.

K) Time to full weight bearing in months.

L) Time to bony union in months.

M) Malunion-0) - None, 1) - One bone, 2) - Both bones

N) Stiffness-0) Absent, 1) Present

O) Range of movements in degrees.

P) Symptoms- A) Knee pain) Ankle pain, C) Hip pain

0) Absent, 1) Intermittent, 2) Restricted

Q) Gait-0) - Normal, 1) Intermittent with support, 2) Always with support

R) Ligament laxity-0)- None, 1)- ACL, 2)- PCL, 3)- MCL, 4)- LCL.

S)Complications.- 0)- None, 1)- Osteomyelitis, 2)- Wound infection, 3) Fat embolism, 4)- Compartment syndrome, 5) Septicemia, 6) Non union, 7) Urinary tract infection, 8) Deep vein thrombosis.

T) Repeat surgery.0) - None, 1) Bone grafting, 2) Plate, 3) Nail, 4) Ilizarov, 5) Amputation,

6) Dynamisation, 7) Refused Surgery 8) Quadricepsplasty, 9) Implant removal, 10) Sequestrectomy, 11) Wash out.

U) Shortening-0) - None, 1) - One bone, 2) - Both bones

V) Malangulation-0) - None, 1) - One bone, 2) - Both bones

W) Squatting-Y- Yes, N- No.

X) Follow up in months.

Y) Karlstrom and Olerud score- E- Excellent, G- Good, F- Fair, P- Poor.

Z) MESS score.

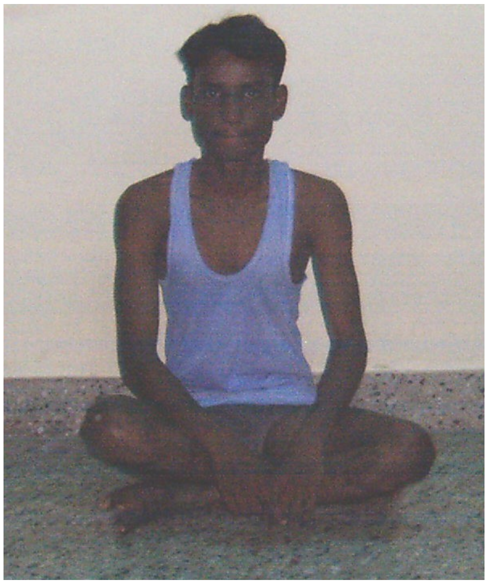
AA) Time to surgery in hours

AB) Articular reduction-0) - Good articular reduction, 1) - Poor articular reduction

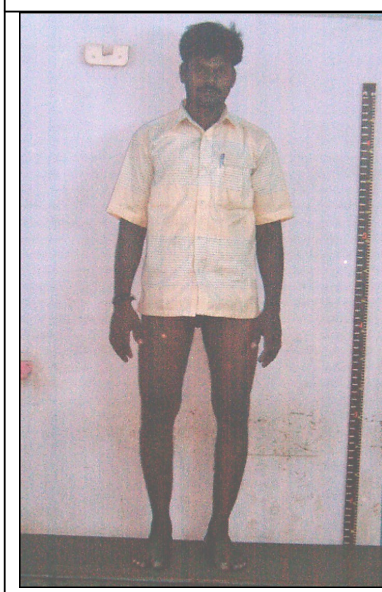
AC) Letts classification-A) Type A, B) Type-B, C) Type-C, D) Type-D, E) Type-E.

AD) Time to admission in emergency department after injury

Excellent Result



Good Result



FOLLOW UP

Fair Result

	
 FOLLOW UP	

Poor Result

POST OP

FOLLOW UP